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A

HANDBOOK OF HYGIENE

AND

SANITARY SCIENCE

BY

GEORGE WILSON, M.A., M.D., & C.M. (EDIN.), F.C.S.

MEDICAL OFFICER OF HEALTH FOR THE MID-WARWICKSHIRE
SANITARY DISTRICT
FORMERLY MEDICAL OFFICER H.M. CONVICT PRISON, PORTSMOUTH

FOURTH EDITION

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6

HANDBOOK OF HYGIENE

domestic hygiene; and I may here be allowed to state that I have nearly completed a supplementary work on that subject, which will shortly be published.

In the preparation of the present edition I have again to express my obligations to the *Sanitary Record*, *Lancet*, *British Medical Journal*, *Practitioner*, and other publications, for much valuable information, which is duly acknowledged in the text. My best thanks are also due to Dr. Buchanan, the Assistant-Medical Officer of the Local Government Board, for supplying me with copies of the official memoranda which are given in the Appendix, and of recent reports made by the Medical Inspectors of that Department on the more important outbreaks of disease and other investigations.

G. W.

23 CLAREMONT ROAD,
LEAMINGTON, *November* 1879.

PREFACE TO THE THIRD EDITION.

THE first edition of this work, which appeared not long after the passing of the Public Health Act, 1872, was so favourably received that a second was called for within six months, and this too has been out of print for nearly a year. The delay in the preparation of the present edition, although to me a matter of deep regret, is in great measure due to my desire to make the work still more worthy of continued confidence, and to spare no pains in incorporating all the more important facts and details connected with the recent rapid progress of sanitary science.

In the preface to the first edition I expressed my great indebtedness to the standard work of the late Dr. Parkes, and I wish now to acknowledge what his own kindliness of heart and diffident nature would not permit me to acknowledge before—that it was under his encouragement that the work was first written, and that all the proof-sheets were submitted to him, at his own request, as they issued from the press. To an untried author in sanitary science such counsel as his was invaluable; and though I might eulogise his memory in other and more eloquent terms, I cannot do so more sincerely than by expressing, in this simple way, my heartfelt obligations to him, which never can be forgotten.

Amongst other numerous works which I consulted in the preparation of the first edition, I desire especially to mention Mr. Simon's Reports to the Privy Council; Dr. Letheby's work on food; Captain Douglas Galton's work on the construction of hospitals; and the writings of Dr. Carpenter, Dr. Angus Smith, Dr. Hassall, Mr. Rawlinson, Mr. Eassie, and Professor Rankine. Full acknowledgment of other authors is given in the proper places.

In the preparation of the present edition I have to acknowledge my obligations to the *Sanitarg Record, Public Health, Lancet, British Medical Journal, Medical Times and Gazette, Practitioner*, and, more especially with regard to systematic details and authentic information of all kinds, to Mr. Simon's new series of Reports to the Local Government Board, the Sixth Report of the Rivers' Pollution Commissioners, and the more recent Reports of the State Board of Health of Massachusetts.

Every chapter has been carefully revised and amended, several have been entirely re-written, and a chapter has been added on water-analysis, for the revision of which I have to express my thanks to Dr. Bond of Gloucester. Although I have endeavoured to cancel wherever I could without impairing the completeness of the work, and have striven to be concise throughout, the amount of new matter which has been added or interpolated has increased the size of the volume by more than a hundred pages. Notice has been taken, or excerpts made, of all the more important of the recent outbreaks of disease which have been traced to polluted milk, polluted water, or foul air; and a large amount of new information has been inserted in respect to water-supply, drainage, and the disposal of sewage, sanitary engineering, infectious hospitals, and preventive measures. The passing of the Public Health Act, 1875, has also necessitated the re-writing of the chapter on the duties of medical officers of health, and in addition to many new practical hints derived from my own experience and that of other health officers concerning these duties, I have written a special section on the important subject of vital statistics. Instead of the excerpt of the Sanitary Acts which appeared in the appendix of the two previous editions, but which is now no longer required, I have inserted a number of official memoranda kindly supplied to me by Dr. Buchanan, Assistant-Medical Officer of the Local Government Board, and have added other data which it is hoped will prove equally valuable.

Although the work has been specially prepared for the use of medical officers of health, I have so arranged it that it may be welcomed as a text-book of sanitary science by medical students, and, as a handy book of reference, by medical practitioners generally. In practical details and freedom from technicalities it is also designed to be serviceable to sanitary authorities, sanitary engineers, architects, town-surveyors, sanitary inspectors, and, in short, to all those outside the profession who are interested in sanitary progress.

For the encouraging and kindly tone of all the criticisms which have reached me, I have, in conclusion, to express my warmest thanks.

G. W.

LEAMINGTON, *Dec.* 1876.

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CHAPTER I.—INTRODUCTORY.

PUBLIC HEALTH AND PREVENTABLE DISEASE.

PUBLIC HYGIENE may be defined as that branch of sanitary science which concerns the physical condition of communities. It embraces a consideration of the various influences operating upon society, whether for its material good or its actual deterioration, with the view of extending the former, and preventing, or ameliorating, as far as possible, the effects of the latter. It involves the enactment of laws by which the safety of the whole may be protected against the errors of a part, and, above all, it aims at the prevention of disease by the removal of its avoidable causes. In a wide sense, therefore, the science of public hygiene enlists the services of the people themselves in continuous efforts at self-improvement; of the teachers of the people, to inculcate the best rules of life and action; of physicians in preventing as well as curing disease; and of law-givers, to legalise and enforce measures of health-preservation. But while it is the special province of the medical profession, as guardians of the public health, to study the causes of physical deterioration and disease, and to point out how far these causes may be controlled or averted, the general well-being of the people must mainly depend on their own exertions and self-restraint. Sanitary improvements in man's material surroundings will not compensate for social transgressions against laws of morality; for public virtue is essential to public health, and both to national prosperity.

The time, however, has gone by when people can be dragooned into cleanliness or be made virtuous by police regulations, and hence it is that the most thoughtful among practical reformers of the present day base their hopes of sanitary progress on the education of the masses as the real groundwork of national health. The people must be taught that good conduct, personal cleanliness, and the avoidance of all excesses, are the first principles of health-preservation; that mental and physical training must go hand in hand in the rearing and guidance of youth; and that morality does not consist so much in a blind observance of the formulæ of empty creeds as in a hearty submission to precepts of health. Nor is this all. They must be interested systematically in the general results of sanitary progress, and become more intimately acquainted with the social and material causes by which it is impeded. Unless a knowledge of these fundamental principles of hygiene be widely disseminated amongst them, it is in vain to expect that legislative enactments, however well devised, will succeed in raising the standard of public health to any considerable extent. But there are hopeful signs of progress even in this direction. The teaching of physiology and the laws of health, which is being gradually introduced into many schools, will doubtless be productive of much good amongst the rising generation; while the large share of attention which the discussion of sanitary questions is already receiving in the public press is the best evidence of the steady growth of intelligent conviction as regards all matters affecting the preservation of health and the prevention of disease.

Taking, then, this wide view of the scope of public hygiene, it will, I trust, prove alike interesting and useful if, by way of introduction, I give a brief historical sketch of its various phases, and more particularly of its progress during recent years. For sanitary science, in the broad sense of the term, is knit up with the life-history of every nation, and enters largely into the history of civilisation. It figures prominently in the Mosaic code of the Jewish race, and its instructions and preventive measures, as exemplified in that code, have accounted largely for the greater comparative longevity of the Jews, for their extraordinary immunity from the recurring epidemics of the Middle Ages, and for the wide-spread, though silent influence, which they have long exercised, and still exercise to the present day.

Or let us glance at those grand old Greeks who have left us such a rich store of philosophy, literature, and art. It is true that though their sanitary code, propounded by Lycurgus, was severe and cruel, yet the means which they adopted in the care and cultivation of their bodily physique, and the development of their intellectual faculties, made them the civilisers of the old world and the exemplars of modern times. But the Greeks, with all their wisdom and physical culture, knew very little of the causes of disease as it affects communities, and they accepted the terrible epidemics with which they were visited as manifestations of offended deities, or, at the best, as afflictions which could neither be avoided nor prevented. Their decline and fall as a nation were due to the luxury into which they lapsed, and the lax morality which ultimately became their ruin and opprobrium.

Referring, now, to the Romans, the other powerful nation of antiquity, we find that though they contributed but little to sanitary science they have left some wonderful examples of sanitary engineering on a large scale. Their *Cloaca Maxima*, for example, and the aqueduct for conveying water from the hillsides, some thirty miles from Rome, to the city, were works of such stupendous magnitude that they have seldom been equalled or surpassed even at the present day. But the Roman Empire, like that of the Greeks, was destined to pass away, and those who have studied the social causes of its decay attribute its ultimate decline in no small degree to the epidemics which repeatedly devastated the population in the early centuries of the Christian era.

We next pass on to what have been termed the dark or Middle Ages, and to the health history of England. The accounts at first are very meagre, but when they become more numerous and reliable they tell us of frequent visitations of plague, pestilence, and famine — mixed up with stories, strange and incredible, of armies fighting in the air, showers of blood, terrible earthquakes, and the like—all of them showing how deep-rooted was the belief in the supernatural as regards epidemic disease and its causes. If, however, we look at the habits and habitations of our forefathers we have no difficulty in accounting for the fearful mortality which prevailed amongst them. Personal cleanliness was utterly neglected. Clothing was immoderately thick and warm, and was seldom changed night or day. The diet was coarse, consisting chiefly of flesh meats highly seasoned. Strong wine or ale was drunk early in the morning, and often far into the night; in short, gluttony and intemperance were prominent characteristics of the sturdy fighting Briton of mediæval times.

Then, as regards his dwelling, we find that the towns and villages were composed for the most part of hovels, with mud walls and thatched roofs. "The floors of the houses," to quote from a well-known letter of the learned Erasmus, "were generally made with loam strewn with rushes, constantly put on fresh without removing the old, lying there in some cases for twenty years, concealing fish bones, broken victuals, and other filth," so that one can quite credit him when he says farther, "if even twenty years ago I had entered into a chamber which had been uninhabited for some months, I was immediately seized with fever." The streets were unpaved, generally covered with clay and rushes, concealing all sorts of abominations; moreover, they were dark, narrow, and tortuous, and without sewers or drains. The rural population, on the other hand, were scattered in slight hovels over wild woods, dreary wastes, and undrained marshes, so that ague and rheumatism were always rife amongst them, and in times of scarcity, which were common enough, they were sure to suffer from famine. Add to all this, that there was constant fighting of some sort going on. Kings were warring against powerful subjects or foreign foes. Cities and towns were walled-in fortresses; and the roads were beset with marauders and highwaymen. Dogberries watched the streets but did not ward them, bravoes stabbed, burglars were plentiful, and amongst all classes life was held very cheap. Those, indeed, were days in which Mr. Darwin's doctrine of survival of the fittest was exemplified to the fullest extent; the weakly went to the wall, and left, on the whole, only those of iron constitutions to perpetuate a brave, hardy, and pushing race, which increased in numbers slowly, if at all, for centuries.

We thus see that conditions inimical to health were abundant everywhere. The walled-in cities were highly favourable to overcrowding and stagnant air; the large armies, which were in constant motion, conduced greatly to the spread of epidemic disease; while personal uncleanliness and intemperate habits made the people ready victims of disorders of all kinds. It is not surprising, therefore, that fevers and devastating epidemics were prevalent; and as instances in point, I may mention the following, which are recorded on the authority of Dr. Guy in his excellent work on *Public Health*:—For example, in the twelfth century, there were fifteen widespread epidemics and many famines; in the thirteenth century, twenty epidemics and nineteen famines; and in the early part of the fourteenth century there were eight epidemics and more famines. And these epidemics, it should be remembered, were not local outbreaks appearing only here and there, but they spread so far and wide that each and all of them were regarded as visitations of national disaster.

And now we come to the fatal year of 1348, when the Black Death or Great Mortality, as it was called, first appeared in England. It is believed to have been an aggravated outbreak of the Oriental Plague, which was then devastating Europe as it had devastated the East. It was an eminently contagious disease, imported, no doubt, in the first instance, but when once it gained a footing on our shores, it spread with such terrible rapidity, that within a few months almost every town and village throughout the country had been attacked, and in some places only a fourth part of the inhabitants were left alive. In London alone, 100,000 fell victims to the disease, and 50,000 corpses were interred in one burial-ground, heaped together, layer upon layer, in large pits. Throughout Europe it has been estimated that twenty-five millions, or a fourth part of the entire population, were swept away. Imagination fails to realise the misery and horrors of the time. The sick died untended, charity was dead, and hope extinguished—everywhere there was terror and black despair.

Without noticing other epidemics which followed the epoch of the Black Death, the next great pestilence which ravaged the country, and known as the Sweating Sickness, broke out in 1485. Unlike the Black Death and the Oriental Plague, which reappeared in the sixteenth and seventeenth centuries, it did not originate in a foreign country to be conveyed by infection to our own shores, but it sprang into existence in this, and was no doubt generated and propagated by the insanitary conditions of dwellings and towns, and the filthy and intemperate habits of the people. For the most part it attacked robust middle-aged adults, men fond of good living, and those amongst the poorer classes who were described as "idle persons, good ale drinkers, and tavern-haunters." Its onset was quick and its termination rapid, the victim generally dying within twenty-four hours; while the mortality was so great that in many parts of the country half of the male adult population were swept away. During the latter part of the fifteenth century, and the first half of the sixteenth, this pestilence reappeared no less than five times, its last visitation having occurred in 1551. Yet it must not be forgotten that this sixteenth century, with its long list of ravaging diseases, gave us, nevertheless, the heroes of the Elizabethan age, our triumph over Spain, and our English Reformation. But progress in sanitary defence was slow, tedious, and tentative. Indeed, the extraordinary vitality and indomitable pluck of the English race would almost appear to have been the sole defences against national decay and disaster, for during long years to come there was but little improvement in the homes or habits of the people. It was not until the Plague, which was the next great pestilence after the Sweating Sickness, had repeatedly devastated the country, and the great fire which swept away the crowded and filthy homes of London in 1666 occurred, that people began to appreciate, though in a faint and glimmering way, the principles of prevention. The plague died out with the fire, but smallpox, jail fever, malignant sore throat, ague, scurvy, and other controllable diseases still continued to contribute to the excessive mortality of the seventeenth century.

But now we come to the dawn of a better day. The gradual improvements in agriculture, manufactures, and commerce were adding steadily to the comforts of life. Food was becoming more plentiful, and the diet less coarse. Vegetables, and more especially the potato, were becoming much more generally used; fresh meat was taking the place of salted meat, which had hitherto constituted such a large part of the English dietary; while tea and coffee were to some extent replacing the strong ale and ardent spirits which had formerly proved such a baneful source of disease. People, too, were beginning to recognise the value of cleanliness of person and home. The introduction of soap and soda made washing easier, and cotton and linen articles of clothing were gradually coming into more general use. Thus far, then, it may be said that the seventeenth century, although characterised by no great advance in sanitary progress, witnessed, nevertheless, some considerable improvements of an incidental and indirect kind. The gradual emancipation from the thraldom of filth had begun, and precautionary measures against the spread of disease in the form of a rough and ready system of quarantine were here and there attempted. But the great purifier of the century was the memorable fire of London, which consumed everything from the Tower to Temple Bar, destroying 81 out of the 97 parishes within the city boundaries, and two of the parishes outside the walls. The old wooden houses with their overhanging stories, and the huge sign-boards swinging across the narrow, winding, filthy, unpaved streets, were swept away; and though the model city which Sir Christopher Wren had planned was not destined to be realised, better houses were constructed, wider streets laid out, and sanitary conditions in other respects were considerably improved.

Coming now to the health history of the eighteenth century, we find that three terrible scourges, namely, the Black Death, the Sweating Sickness, and the Plague, have finally disappeared from the bills of mortality. And their disappearance, as we have seen, is not to be attributed to any conscious or well-sustained efforts in the way of prevention, but to the silent influence of the onward progress of civilisation. We now, however, enter upon an era in which observation and induction begin to play a part in the prevention of human suffering, when the physical causes of disease receive fuller appreciation, and when it is at last recognised that these causes can be inquired into and dealt with in a scientific manner. It is true that the workers were few, but the results of their labours have been fraught with untold blessings to humanity. Foremost amongst these pioneers of sanitary science we find the honoured names of Captain Cook, John Howard, and the immortal Dr. Jenner; and now let us glance briefly at the good work which they accomplished.

Captain Cook's name is associated with the suppression of the once prevalent disease—scurvy; a disease which, up to the latter half of the eighteenth century, decimated our armies and fleets, and often proved terribly fatal amongst the civil population. It is a disease easily recognised and well-defined; fostered, as many other diseases are, by insanitary conditions; but its real cause is a diet from which vegetables and fruits have been excluded, and therefore its prevention or cure depends upon a proper supply of vegetable food or vegetable juices. It is true that all this had been known or surmised long anterior to the period in question; but it was reserved for Captain Cook, in his first voyage of discovery round the world, from 1772 to 1775, to prove beyond a doubt that the disease could be banished from every ship's crew, and that it could be entirely eradicated on land and sea. Hitherto, it had been a cause of great mortality amongst seamen; and, to quote one instance out of many, in Anson's famous expedition some thirty years previous to that of Captain Cook, out of a total number of 900 hands 600 died before the expedition returned, and chiefly from scurvy. During Captain Cook's three years' voyage, on the other hand, there were only four deaths, namely, three from accident and one from consumption, out of a total number of 118 men. Captain Cook thus earned for himself a foremost place amongst the sanitary reformers of the eighteenth century; but the nation took years to learn the lesson which he taught, and many more lives had to be sacrificed before it became compulsory that lime-juice should form a part of the commissariat of every sea-going vessel. Scurvy, too, may now be reckoned among the diseases of the past, although it occasionally re-appears, as in the late Arctic expedition, but only through blameable neglect or some other mishap.

The next great reformer, deserving of special notice, was the great and good John Howard. His name, as every one knows, is associated with the prevention of a fatal disease, then known as the jail-fever, which was constantly breaking out in prisons all over the country, had often invaded our courts of law, and made several assizes memorable as the Black Assizes, and which was continually spreading by means of infection, through the agency of discharged prisoners and debtors, amongst all classes of the community. The disease has long since been recognised to be the same as typhus fever, and John Howard lived the life of an apostle and died a martyr in proving that it is a disease which is essentially due to filth and overcrowding. Without enlarging on the incidents of his self-sacrificing labours, the outcome of them is simply this—that for years back the prisons of this country have been proved by the most rigid statistics to be far healthier than our homes, and that so-called preventable disease of any kind is of such rare occurrence within their walls, that when any isolated cases do appear they at once give rise to surprise, and are sure to call for inquiry.

The next great sanitary triumph of the eighteenth century calling for special notice was the discovery of vaccination. That most hideous and terribly fatal disease, smallpox, had long been a terror and scourge to all classes of the community here and abroad, and after the disappearance of the Plague became the severest epidemic of the country. The introduction of the practice of inoculation at the instance of Lady Mary Wortley Montague, the wife of the English Ambassador at Constantinople, which took place somewhere about the year 1720, while it modified the severity of the disease, assisted rather than otherwise its spread. But whether this was so or not, we find from the bills of mortality of the time that during the ten years 1771 to 1781 smallpox was the cause of 100 out of every 1000 deaths in London, and there is reason to believe it was quite as fatal in other parts of the country. The practice of vaccination, Jenner's grand discovery, was commenced in the year 1796, and although it was several years afterwards before it became general, its value as a preventive measure was not long in declaring itself in a steadily declining mortality. Thus, according to well authenticated returns, while the mortality was 88 per 1000 deaths in the last ten years of the eighteenth century, it has fallen progressively from 64 to 11 per 1000 deaths during the first six decades of the present century. And if we have still recurrent outbreaks of the disease, it is because there are thousands of people living at the present day who never have been protected by vaccination, and many thousands more who have been imperfectly vaccinated. For it should be remembered that it was not till 1840 that we had any vaccination laws at all; not till 1853 that vaccination was provided gratuitously for the poor; and not till 1867 that vaccination was made compulsory amongst children generally. We may therefore expect occasional outbreaks, though of constantly decreasing severity, for years to come; but that the disease can and will be finally eradicated, the belief is as deep-rooted and strong in the minds of medical men and of the educated public of the present day as it was in the stout brave heart of Edward Jenner.

In addition to these great sanitary triumphs of the eighteenth century there were others, such as improvements in ventilation and better house accommodation, which were also contributing their share in lessening the general death-rate, and especially in the reduction of fevers of all kinds. Diseases amongst infants and young children were much less fatal at the close than at the beginning of the century, while the labours of John Howard were beginning to tell on the home habits of the people, as they had already told on the vast improvement which had been effected in the sanitary condition of prisons and jails. The health of our soldiers and sailors was much better cared for, and the sickness and mortality greatly reduced. Altogether, the progress made in the actual prevention of disease was very considerable; and accordingly, we find from the bills of mortality that the death-rate of the city of London, which in the seventeenth century was over 80 per 1000, had been reduced to 50 per 1000, and for years back it has averaged only 24 per 1000.

Coming now to the beginning of the present century, we find the country engaged in that long fierce struggle with France which culminated in the victory of Waterloo; yet, in spite of the constant drain in men and money, the population kept steadily increasing and the public health slowly improving. But outside London there were no large towns teeming with over-grown populations—none contained so many as 100,000 inhabitants, and only five exceeded 50,000. By and by, however, there came a sudden and unprecedented change in the social history of the country. The discovery of steam-power opened up new sources of industry of almost unlimited extent and variety. Commerce flourished as it had never flourished before; wealth accumulated; work became plentiful; living became easier; early marriages were encouraged; and the rapid increase of population begun then has continued ever since. The population of England and Wales, which, in round numbers, was only ten millions in 1810, had increased to over fifteen millions in 1838; and at the present day it nearly amounts to twenty-five millions. And this enormous increase, it should be remembered, has taken place almost exclusively in already populous towns, or at centres of industry which speedily became populous. But under what conditions? For the most part in the dust and din of factories; the vitiated air of mines; the stifling atmosphere of workshops; the bustle of busy warehouses; and when the day's work was done, in over-crowded houses or under-ground cellars, heaped together in filthy, narrow, and unventilated streets or reeking back slums. Even in the construction of better class houses the veriest rudiments of sanitation were neglected, because they were still but little understood and less appreciated. Instead of municipal control there was general apathy. Sewers had to be constructed, but they were of the worst possible description, uneven, leaky, unventilated, and incapable of being flushed, while the house drains leading into them were quite as faulty and imperfect. Scavenging was neglected, filth accumulated everywhere, cess-pits multiplied, and wells became polluted. But why fill up the disgusting details of the picture? The mischief was done, and in spite of recent improvements and legislative enactments, it will take years of steady, earnest, sanitary work, and millions of money to undo it. The money, no doubt, will be forthcoming, and the cleansing of the Augean stables may be accomplished in time, but the squalor, the misery, the disease, the physical deterioration, and the moral degradation engendered, have imposed a load of vitiated heritage which will tell on generations yet unborn, and which at the present day is crushing thousands of children into an early grave.

Meanwhile the Legislature had done nothing, or next to nothing, to mitigate the terrible evils which were fast accumulating. With the exception of the Factory Act of 1833, and the Poor Law Amendment Act of the following year, no public measures of general importance had been attempted, and even these were haphazard and tentative. It is true that here and there local Acts had been applied for and granted by Parliament to empower town authorities to provide water supply and drainage, but it was not till those wonderful series of returns of the Registrar-General, and the masterly reports of Dr. Farr which accompanied them, began to be published, that public attention became thoroughly aroused. At last, thanks to the incessant labours of Edwin Chadwick, Dr. Farr, Dr. Southwood Smith, Dr. Guy, and other pioneers of sanitary progress, the Health of Towns' Commission was appointed, and their first report appeared in 1844, a report in which the relations of cause and effect, as applied to disease, were made so glaring and manifest, that among the intelligent portions of the community there arose a loud cry for legislative interference. Things are still bad enough in the present day, but few can form any adequate conception of the deplorable sanitary condition of the country when that report was published. From every large town to which the long list of queries was sent, there came, with but little variation, the same terrible series of replies—bad drainage, polluted water, unhealthy houses, overcrowding, filth everywhere; and, as a consequence, an excessive death-rate, with fever and filth-diseases of every description adding enormously to the death-roll. But so powerful were vested interests, and so strong the opposition to interfere with the liberty of the subject or of corporate bodies, that it was not till the country was threatened with a second visitation of cholera as severe as the epidemic of 1831, that Parliament became alarmed and passed the Public Health Act of 1848. Under this Act the General Board of Health was constituted, with a staff of inspectors who were empowered to hold public inquiries and report on the sanitary condition of towns which, according to the returns of the Registrar-General, showed an excessive rate of mortality. The Act itself was eventually adopted or enforced in a great many towns throughout the country, but as it was of a permissive nature, like the great majority of the sanitary Acts which followed it, the beneficial results which might have been expected to accrue from it were long in appearing, and were by no means general. Nevertheless, it originated an era of active sanitary improvement in most of our large towns, and it merits special notice as the first outspoken recognition on the part of the Legislature that the health of the State concerns the statesman. By enabling town authorities to borrow money and spread the expense of public works over a number of years, it removed one of the greatest obstacles to sanitation, and, as a consequence, extensive schemes of sewerage and water-supply were soon undertaken in many parts of the country. But, unfortunately, the engineers of those days largely shared the general ignorance of sanitary principles which then prevailed. Sewers were badly constructed, insufficiently ventilated, and unflushed; many of them, in fact, were elongated cesspools, and the sewage itself, collected at one or more outfalls, was discharged into the nearest stream, thereby creating a general befoulment of our rivers, which, in spite of numerous injunctions, became so serious as to call for a special Act, which was passed in 1876 under the title of the Rivers' Pollution Act.

Among other Acts which followed the Public Health Act of 1848 may be mentioned the Common Lodging-Houses' Act of 1851, the Labouring Classes Lodging-Houses' Act of the following year, the Metropolis Management Act of 1855, and the Nuisances Removal Act and the Diseases Prevention Act, both of the same year. But during the interim the nation had been learning another terrible lesson in sanitation. The horrors of the Crimean war, engendered by a faulty commissariat, an utter neglect of scavenging and cleanliness, and an incredible disregard of the most rudimentary laws of health, at last aroused and excited the public mind to the point of indignation, and so in 1857 was instituted the Royal Commission on the health of the Army. Their report, which is still of the greatest value, was soon followed by the reports of the Barrack and Hospital Commission, and of the Commission on the Health of the Army in India, all of which demonstrated in the most complete manner that the sick-rate and death-rate of the army were culpably excessive, while the adoption of their recommendations, under the able teaching of the late lamented Dr. Parkes, afforded such conclusive proofs of the grand policy of prevention, that a stimulus to sanitary reform began to permeate the more intelligent classes among the general community which has continued to increase ever since.

The powers of the General Board of Health were transferred by Act of Parliament to the Privy Council in 1858, and in the same year the Local Government Board

Act was passed, which consolidated to some extent the previous Sanitary Acts which were in force. The appointment of Mr. Simon as medical officer to the Privy Council, with his able staff of medical inspectors, inaugurated a new era in civil life. The material causes of disease were investigated with a minuteness and completeness of detail which could not fail to influence the most sceptical, and the series of reports in which these investigations are embodied and commented on have become the classics of sanitary literature. To any one who takes the trouble to read these reports, it becomes at once apparent that whatever of purely beneficial sanitary legislation which has subsequently come into force has all along been largely indebted to Mr. Simon's foresight and advocacy, based on the inquiries of such able coadjutors as Seaton, Greenhow, Buchanan, Hunter, Thorne, Netten Radcliffe, Ballard, and others. Many of these inquiries will be specially alluded to in various parts of this work, but this brief historical sketch would be incomplete without referring to two discoveries in sanitary science which have already resulted in a vast amount of good, and are destined to be of still greater benefit to the nation. I allude to Dr. Snow's researches with regard to the etiology of cholera (see Chapter VIII.) and the differentiation between typhus and typhoid fever as regards causation and symptoms, and this last deserves special notice.

About the year 1848, when fever was plentiful enough in all our large towns, and did not spare country villages, the present Sir William Jenner, the late Dr. Stewart, and a few other earnest workers in hospital wards, began to observe that among the numerous cases of so-called typhus which came under their care there were many which presented symptoms of a more or less uniform character, but differing in many respects from those which characterised typhus fever. These symptoms soon came to be recognised as those of typhoid or enteric fever, and subsequent inquiries have so clearly established the causes and mode of propagation of the fever that it is now regarded as a disease which is entirely preventable, and one which we have every reason to believe will eventually be as completely banished from our midst as the ague, which was once so common and now so rare. But it was urged by many, when this disease came to be talked about and written about, and was frequently found to be due to the entrance of sewer-air into houses, that in sewering a town public authorities only increased the danger, and that the money expended was worse than wasted. It is true that there was some show of foundation for this belief, but it has long since been made clear that any outbreaks of the disease which have been traced to sewer emanations were due not to the system itself, but to faulty sanitary engineering. Indeed, in the celebrated report of Dr. Buchanan, who was the inspector appointed to visit a large number of towns and make special inquiry into this subject, there was no point more clearly established than the remarkable reduction which had taken place in almost all the towns where a system of sewerage had been carried out. (See Chap. XIII.)

Without referring to other important inquiries, such as those relating to unwholesome trades and occupations, food-adulterations, polluted water-supply, over-crowding and unhealthy house-accommodation, milk-contamination, and the wide-spread agency of filth in the causation of disease, we may note in passing the principal legislative measures which have recently been enacted to cope with these evils. And among these may be mentioned the Adulteration of Food and Drink Act of 1860; Amendments of the Factory Acts; the Sanitary Act of 1866; the Local Government Board Act of 1871, which vested in one central board the powers previously exercised by the Poor Law Board and the Privy Council; and the Public Health Act of 1872. This last Act divided the country into urban and rural sanitary districts, and necessitated the appointment of medical officers of health and sanitary inspectors, while the Adulteration of Food Act, which was passed in the same year, authorised the appointment of public analysts. Then followed the Public Health Act of 1875, which consolidated the previously existing sanitary Acts; and in the same year were passed an amended Adulteration Bill, and the Artisans' and Labourers' Dwellings' Act, intended to sweep away the rookeries in our large towns. The Rivers' Pollution Act followed in 1876, the Canal Boats' Act in 1877, and the Public Health (Water) Act last year. Reserving the consideration of the strictly medical aspects of these various Acts for a future chapter (see Chapter XV.), it may be remarked in passing that, partly owing to the permissive nature of sanitary legislation, partly to the conflicting opinions and want of harmony which it is well known have hitherto hampered the policy of the Local Government Board, and partly to the supineness of Local Authorities and their aversion to centralisation and Governmental interference, sanitary reform, in spite of all the obligations which the Legislature has imposed, and the measures to carry them out which it has provided, remains, comparatively speaking, at a standstill in many parts of the country. It is true that in many other localities there is abundant evidence of sound sanitary progress, but so long as the Public Health Service is allowed to continue in its present chaotic condition, so long will there be loopholes for the evasion of duty on the part of sanitary authorities, and inducements to remissness on the part of their officers.

This, however, by the way. Let us now consider for a moment the vast amount of preventable disease with which sanitary science and sanitary legislation have still to combat. It has been estimated by Mr. Simon "That the deaths which occur in this country are fully a third more numerous than they would be if our existing knowledge of the chief causes of disease were reasonably well applied throughout the country; that of deaths, which in this sense may be called preventable, the average yearly number in England and Wales is about 120,000; and that of the 120,000 cases of preventable suffering which thus in every year attain their final place in the death-register, each unit represents a larger or smaller group of other cases in which preventable disease, not ending in death, though often of far-reaching ill effects on life, has been suffered. And while these vast quantities of needless animal suffering, if regarded merely as such, would be matter for indignant human protest, it further has to be remembered, as of legislative concern, that the physical strength of a people is an essential and main factor of national prosperity; that disease, so far as it affects the workers of the population, is in direct antagonism to industry; and that disease which affects the growing and reproductive parts of a population must also in part be regarded as tending to deterioration of the race.

"Then there is the fact that this terrible continuing tax on human life and welfare falls with immense over-proportion upon the most helpless classes of the community; upon the poor, the ignorant, the subordinate, the immature; upon classes which, in great part through want of knowledge, and in great part because of their dependent position, cannot effectually remonstrate for themselves against the miseries thus brought upon them, and have in this circumstance the strongest of all claims on a legislature which can justly measure, and can abate, their sufferings.

"There are also some indirect relations of the subject which seem to me scarcely less important than the direct. For where that grievous excess of physical suffering is bred, large parts of the same soil yield, side by side with it, equal evils of another kind, so that in some of the largest regions of insanitary influence, civilisation and morals suffer almost equally with health. At the present time, when popular education (which indeed in itself would be some security for better physical conditions of human life) has its importance fully recognised by the legislature, it may be opportune to remember that, throughout the large area to which these observations apply, education is little likely to penetrate, unless with amended sanitary law, nor human life to be morally raised while physically it is so degraded and squandered." (See *Thirteenth Report of the Medical Officer of the Privy Council.*)

Or, to take another illustration. According to the returns of the Registrar-General, there are fifty-four large tracts of England and Wales whose annual mortality-rate is only seventeen per 1000, less by *five* than the average mortality-rate of the whole country, less by *ten* than in nine districts, and less by *twenty-two* than the mortality reigning for ten years in Liverpool. It therefore appears that there are influences inimical to life prevailing to a far greater extent in some parts of the country than in others, and a closer analysis of the national death-register demonstrates still more clearly that this excess of mortality is, for the most part, due to diseases which in other ways are known to be preventable, and which detailed medical inspections in various localities, at the instance of the Privy Council and the Local Government Board, have proved to be dependent upon causes which are not only removable, but whose very existence constitutes an offence against sanitary law. These causes have been grouped by Mr.

Simon into two great classes, namely, local conditions of filth and nuisance polluting air and water, and reckless disseminations of contagion; and as regards both these wide fields of disease-causation, the various enactments embodied in the Consolidated Health Act of 1875, have conferred extensive powers upon sanitary authorities throughout the country to remove the former, and to see that protective measures and penal checks are fully and fairly carried out with regard to the latter.

But there are some pessimists who maintain that because the average death-rate of the country has remained stationary, with comparatively slight fluctuations, at a little over 22 per 1000 from 1841 to 1870, preventive measures and the vast sums which have been expended on sanitary improvements are alike powerless to increase the mean duration of life. They appear to regard the average age at death which prevailed during that period, as the "limit which nature in her wisdom" has prescribed, and that we have no grounds for believing that public sanitation will ever materially lessen the persistently heavy death-roll of the nation. But such an argument, as has already been made evident, is based on inferences which a closer analysis of vital statistics proves to be altogether untenable. It has been previously shown, for example, that the death-rate in London has been lowered from 80 per 1000 in the seventeenth century, to 50 per 1000 during the past century, and to 24 per 1000 at the present day. Then again, we find that during recent years the death-rate has been very considerably lowered in many other towns throughout the country, and that this diminished death-rate has admittedly and unmistakably been brought about by the sanitary improvements which have been carried out. This is well illustrated by the following table given in the Appendix to Dr. Ransome's excellent address on State Medicine, delivered at the meeting of the British Medical Association in 1877, in which he also proves that in these and other localities where new schemes of water-supply and drainage had been completed, there has been a marked amelioration in diseases classed as preventable:—

Districts of England and Wales, showing some Improvement in the Annual Rate of Mortality in the Three Decades, 1841-50, 1851-60, 1861-70.

Name of District, etc.	Registration County.	Enumerated Population.	Average Annual Mortality.		
			Deaths to 1000 living.		
		1871.	1841-50.	1851-60.	1861-70.
North Witchford	Cambridge	15,585	27	21	20
Whittlesey	Cambridge	7,002	25	23	21
Wisbech	Cambridge	34,209	25	22	20
Orsett	Essex	13,172	24	21	18
Salisbury	Wilts	9,212	28	24	20
Stoke Damerel	Devon	49,449	26	23	21
Wolverhampton	Stafford	136,053	27	28	24
Coventry	Warwick	40,113	27	25	21
Macclesfield	Chester	59,339	26	25	23
Hull	York	68,316	31	25	26
Newport	Monmouth	61,252	24	22	21
Merthyr Tydfil	Glamorgan	104,239	28	29	25
Crickhowell	Brecknock	20,147	27	25	23

It is no doubt true that these reductions have been counterbalanced by increased death-rates, chiefly in the newer towns which have sprung up so rapidly in mining and manufacturing districts, but considering the evils attendant upon overcrowding, and the utter neglect of all sanitary principles or precautions, it may be fairly argued that even a stationary average death-rate ought to be accepted as proof of progress. Moreover, it should be borne in mind that organised sanitary supervision and general local administration do not date farther back than the Public Health Act, 1872, and that therefore the results have not yet had sufficient time to declare then selves, because the evils to be combated were so enormou and the supineness to encounter them is in many par of the country still so apparent. Notwithstanding a this, however, it is satisfactory to note that apart from diminution of the death-rate in particular localities, the: has been a real and sensible decline in the average r corded death-rate of England and Wales during the pa few years. Thus, while the average annual death-ra during the thirty years 1841-1870 was 22·37 per 100 the average death-rate during the period 1871-1878 w 21·65, and, according to the returns of the Registra General for the quarter ending in June of the prese year, the annual death-rate from fevers alone has steadi declined from 0·63 per 1000 to 0·33 in 1878, or nearl one-half.

But in order to carry on this combat against preven able disease to a successful issue, we want a thorough organised Public Health Service, with efficiently train health officers who shall be debarred from private practic and competent sanitary inspectors, all of them holdi permanent appointments under the control of the Loc Government Board. We also want hospital accommod tion within easy access in every populous district for t isolation of cases of infectious disease, and compulsory a early information of all such cases, and we want, mor over, what is still very hard to get, the active a intelligent co-operation of the people themselves in i proving and maintaining the sanitary condition of t home and its surroundings. Many, too, look hopeful forward to the vast benefits which would accrue if t relations between the public and medical profession, which sanitary science owes so much, were entirely alter Hitherto, the public generally have only enlisted t services of the profession when disease sets in, but it contended, and with reason, that it would be a far wiser policy to pay the medical attendant so much a year, and thereby enlist his services in conserving the health of the household. To a certain extent this policy is already carried out in club-practice and provident dispensaries, but there would be no difficulty in carrying it out as regards all classes of the community, if people could only be persuaded that it would be to their ultimate advantage, while the rate of remuneration to be paid to the medical attendant could be easily arranged on a fair and equitable basis. For it need hardly be said that so long as medical men are paid solely and simply for attempting to cure, it is obviously not to their interest to exercise their knowledge and skill in preventing disease, true though it be that the efforts of the profession generally are seldom lax in controlling those diseases which, without their intervention, would be sure to spread. Nor should it be overlooked that there is a long list of other diseases, appertaining to the domain of domestic hygiene, such as those resulting from a vitiated heritage, intemperance, errors in diet, and irregular habits or modes of life, which might be largely controlled if the services of the medical practitioner were thus enlisted in the grand policy of prevention. But, unfortunately, the public credulity in the power of cure still reigns paramount, while their faith in prevention lies practically dormant, and hence it is that quackery of every description continues to thrive, and the pills and potions which are so extensively advertised find a ready sale. This, however, is a matter in which the people themselves must take the initiative, and it has only been adverted to here in order to show how curative and preventive medicine might cordially go hand in hand for the promotion of the public health and the abatement of human suffering.

CHAPTER II.—FOOD.

SECTION I.—FUNCTIONS AND CONSTITUENTS OF FOOD.

WITHOUT entering into a discussion of the various chemico-physical changes which food undergoes in the living body, it may be broadly asserted that its ultimate destiny is the development of heat and other modes of motion, which together constitute the physiological phenomena of animal life. The potential energy with which the food is stored becomes converted into actual or dynamic energy, and is manifested in the body as heat, constructive power, nervo-muscular action, mechanical motion, and the like. But as food also supplies the materials which are requisite for the development and maintenance of the living fabric, as well as for the display of its various kinds of active energy, it may be inferred that inorganic and organic substances are both necessary. The organic alone are oxidisable, or capable of generating force, while the inorganic, though not oxidisable, are essential to the metamorphosis of organic matter which takes place in the animal economy.

The organic constituents of food are generally divided into nitrogenous, fatty, and saccharine compounds; and the inorganic into water and saline matters. Both classes of constituents are present in all ordinary articles of diet, whether they be derived from the animal or vegetable kingdom.

1. *Functions of the Nitrogenous Constituents.*—The nitrogenous constituents consist of albumen in its various

forms, fibrine, syntonin or muscle-fibrine, casein, gluten, legumin, and other allied substances, such as gelatine. Their chemical composition is remarkably uniform, and, as they seem all capable of being reduced by the digestive process to a like condition, they can replace each other in nutrition, though not to an equal extent.

Up to a comparatively recent period, it was believed that nitrogenous constituents must first be converted into tissue before their dynamical energy can be elicited; in other words, that muscular force is entirely dependent on the metamorphosis of muscular tissue, and that urea, being the product of the change, ought to be regarded as a measure of the force. This was the doctrine taught by Professor Liebig, and it was generally accepted by physiologists until Drs. Fick and Wislicenus of Zurich published their famous experiments connected with their ascent of the Faulhorn. While these experiments proved that a non-nitrogenous diet will sustain the body during severe exercise for a short period, and without any notable increase in the amount of urea, the more carefully conducted experiments subsequently made by Dr. Parkes showed that *possibly* the amount of urea is even lessened. If this view were confirmed, Dr. Parkes' inference would be rendered highly probable—the inference, namely, that muscle, instead of oxidising during labour, and becoming wasted by losing nitrogen, does in reality appropriate nitrogen, and grows, and that its exhaustion does not depend so much on decay for the time being, as on an accumulation of the oxidised products of other food constituents within its tissues. He takes care to point out, however, that in the long run some decay of muscle does take place, and that the amount of nitrogen must be increased as the work increases. The still more recent researches of Dr. Pavy in the case of Mr. Weston, so well known for his pedestrian feats, appear to indicate that at the commencement of a prolonged muscular effort, the nitrogen excreted is considerably increased, and that subsequently it will vary pretty much according to the amount contained in the food consumed from day to day.

Judging from these and other experiments, it would therefore appear that, although the main functions of the nitrogenous constituents of food are the construction and repair of the tissues, they exercise other important functions of a regulative and dynamic nature not well defined. There is no doubt that a certain portion of them is directly decomposed in the blood, and so far they contribute to the maintenance of animal heat and the development of dynamic energy; but the experiments of Pettenkofer and Voit also tend to show that the nitrogenous substances composing the tissues determine the oxidation of the other constituents, or, in other words, that no manifestation of force is possible without their participation in the process.

2. *Functions of the Fatty Constituents.*—The fact that food containing a large proportion of fatty ingredients is invariably used by the inhabitants of cold countries, indicates that these constituents play an important part in the maintenance of animal heat. Indeed, it has been proved by experiment that the respiratory or heat-producing powers of fat are twice and a half as great as those of the other hydrocarbons, as starch or sugar. Fat also takes an active share in the conversion of food into tissue, and aids the removal of effete products from the system. The experiments already alluded to likewise show that its oxidation in the blood generates to a great extent the force which is rendered apparent in locomotion or manual labour. Further, its distribution in the tissues gives rotundity to the form, serves to retain animal heat by its non-conducting properties, and greatly facilitates

the working of the various parts of the living machine by lessening friction and preventing jarring by its elasticity.

3. *Functions of the Saccharine Constituents or Hydrocarbons.*—These constituents comprise cellulose, starch, and sugar; and, like the fatty constituents, are directly subservient to the maintenance of animal heat and the production of animal force. Starch is for the most part converted into dextrine, and by a further oxidation generates carbonic acid, which is given off by the lungs. As already stated, the heat-producing powers of these constituents are much inferior to those of fat, but they are capable of being converted into fat in the system, and are largely concerned in carrying on the digestion of nitrogenous substances.

4. *Functions of Water and Saline Matters.*—The principal functions of water in the animal economy are—the solution and conveyance of food to different parts of the system, the removal of effete products, the lubrication of the tissues, the equalising of the body temperature by evaporation, and the regulation of the chemical changes which take place in the processes of nutrition and decay. Saline matters, on the other hand, are the chief media for the transference of the organic constituents throughout the body. They are largely concerned in the consolidation of the tissues, and are supposed to convert unabsorbable colloids into highly diffusive crystalloids.

The functions of what are called the accessories of food, such as beverages, stimulants, etc., are still matters of speculation.

That all these four classes of constituents should be present in a well-arranged dietetic scheme is alike taught by experience and proved by experiment. No single class is capable of sustaining life by itself, although it is certain that health can be maintained for some time on a diet consisting of the nitrogenous, fatty, and saline matters.

The separate amounts and relative proportions of the several classes of constituents required in a standard diet for a healthy male European adult, of average size and weight, and performing a moderate amount of work, are given in the following table:—

AMOUNTS.		GRAMMES.	RELATIVE PROPORTIONS.
Water-free Substances given daily.	Ounces avoir.		
Nitrogenous substances .	4·587	130	1
Fatty ,, .	2·964	84	·6 nearly.
Saccharine ,, .	14·257	404	3
Saline ,, .	1·058	30	·2
Total water-free food .	22·866	648	

Although no single standard will meet all cases, the above which is quoted from Moleschott's numbers, is found to accord fairly with the observations of numerous other physiologists.

SECTION II.—NUTRITIVE VALUES OF FOOD.

As the phenomena of nutrition depend mainly on the chemical interchanges of nitrogen and carbon with oxygen different articles of diet have been estimated according to the amount of nitrogen and carbon which they contain But inasmuch as the actual value of the carbonaceous compounds in fatty constituents is about two and a hal times as great as that of the saccharine constituents, it i evident that, in framing a table of alimentary equivalents the amount of carbon must be stated as having the same nutritive value throughout. In the following table, therefore, which is taken from the late Dr. Letheby's valuable work on *Food*, the amount of carbonaceous matters in the different articles of diet is estimated as starch:—

	GRS. PER POUND.			GRS. PER POUND.	
	Carbon.	Nitrogen.		Carbon.	Nitrogen.
Split peas .	2699	248	New milk .	599	44
Indian meal .	3016	120	Skim cheese .	1947	483
Barley meal .	2563	68	Cheddar cheese	3344	306
Rye meal .	2693	86	Bullock's liver	934	204
Seconds flour .	2700	116	Mutton . .	1900	189
Oatmeal . .	2831	136	Beef . .	1854	184
Bakers' bread .	1975	88	Fat pork .	4113	106
Pearl barley .	2660	91	Dry bacon .	5987	95
Rice . .	2732	68	Green bacon .	5426	76
Potatoes . .	769	22	White fish .	871	195
Turnips . .	263	13	Red herrings .	1435	217
Green vegetables	420	14	Dripping .	5456	—
Carrots . .	508	14	Suet . .	4710	—
Parsnips .	554	12	Lard . .	4819	—
Sugar . .	2955	—	Salt butter .	4585	—
Treacle . .	2395	—	Fresh butter .	6456	—
Buttermilk .	387	44	Cocoa . .	3934	140
Whey . .	154	13	Beer and porter	274	1
Skimmed milk	438	43			

As this table contains almost all the articles which are likely to be met with in a common dietary, it becomes no difficult matter to calculate the total amount of carbon and nitrogen which any such dietary yields, and to compare the results with other dietaries that have been calculated in the same way. It is necessary to add that the nutritive equivalents apply to articles in their uncooked state, and that the meat is boned.

SECTION III.—FOOD AND WORK.

It has already been stated that, in addition to maintaining the body in a healthy state, the potential energy of food is the sole source of the active energy displayed in mechanical motion or work. It therefore follows that the diet must be increased as the work increases; an question arises at the outset, What is the minimum am of food on which a man of average size and weigh subsist without detriment to health? From a large ber of observations made by Dr. Lyon Playfair and o on the dietaries of prisons and workhouses, and b late Dr. Edward Smith on the amounts of food cons by the Lancashire operatives during the cotton-fami would appear, according to Dr. Letheby, that a b sustaining diet should contain about 3888 grains of bon, and 181 grains of nitrogen. In round number taking a somewhat liberal view of the question, Edward Smith has proposed the following average representing the daily diet of an adult man and w during periods of idleness:—

	Carbon (grains).	Nitrogen (grai
Adult man . . .	4300	200
Adult woman . .	3900	180
Average adult .	4100	190

These are the proportions which, according to I Smith's researches, are actually required to avert st tion diseases; and they are represented in the case man's diet by 22 oz. of carbonaceous food, with 2· nitrogenous.

Taking the mean of all the researches which been made by eminent physiologists, Dr. Letheby given the following as the amounts required daily adult man for idleness, for ordinary labour, and for a labour:—

Daily diets for	Nitrogenous. Ozs.	Carbonaceous. Ozs.		Carbon. Grs.	Nit
Idleness . .	2·67	19·61	=	3816	[illegible]
Ordinary labour	4·56	29·24		5688	[illegible]
Active labour .	5·81	34·97		6823	[illegible]

Very often the standard for a healthy adult employed at ordinary labour is stated as 20 grammes of nitrogen, and 300 grammes of carbon, equivalent to 308·6 and 4629 grains respectively.

And here it may be observed that the general correctness of these averages is fully borne out by the results of the numerous experiments which have been made to ascertain the amount of carbon and nitrogen actually excreted by adult men under different conditions of diet and exercise. These results have also been summarised by Dr. Letheby, and the averages are found to correspond very closely with those just given, thus :—

Daily Requirements of the Body (LETHEBY).

		Nitrogenous Food. Ozs.	Carbonaceous Food. Ozs.		Carbon. Grs.	Nitrogen Grs.
During Idleness as determined	By dietaries .	2·67	19·61	=	3816	180
	By excretions	2·78	21·60	=	4199	187
	Average	2·73	20·60	=	4005	184
Routine work as determined	By dietaries .	4·56	29·24	=	5688	307
	By excretions	4·39	23·63	=	4694	296
		4·48	26·44		5191	302

The first of these averages is represented by 2 lbs. 2 oz. of bread; and the second by about 3½ lbs., or 1 lb. of butcher meat with about 1¼ lbs. of bread.

The actual amounts of carbonaceous and nitrogenous matters which are consumed by low-fed and well-fed operatives are given in the following tables :—

Weekly Dietaries of Low-fed Operatives, calculated as Adults (Dr. E. Smith).

Class of Labourer.	Bread Stuffs.	Potatoes.	Sugars.	Fats.	Meat.	Milk.	Cheese.	Tea.	Containing	
									Carbon.	Nitrogen.
	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Grs.	Grs.
Needle Women (London)	124·0	40·0	7·3	4·5	16·3	7·0	0·5	1·3	22,900	950
Silk-weavers (Coventry)	166·5	33·7	8·5	3·6	5·3	11·6	1·0	0·3	27,028	1104
Silk-weavers (London)	158·4	43·8	8·8	5·5	11·9	4·3	0·3	0·6	48,288	1165
Silk-weavers (Macclesfield)	138·8	26·6	6·3	3·4	3·2	41·9	0·9	0·3	27,346	1177
Kid-glovers (Yeovil)	140·0	84·0	4·3	7·1	18·3	18·3	10·0	0·9	28,623	1213
Cotton-spinners (Lancashire)	161·8	22·6	14·0	3·1	5·0	11·8	0·7	0·7	29,214	1295
Hose-weavers (Derbyshire)	190·4	64·0	11·0	3·9	11·9	25·0	2·2	0·4	33,537	1316
Shoemakers (Coventry)	179·8	56·0	10·0	5·8	15·8	18·0	3·3	0·8	31,700	1332
Farm labourer (England)	196·0	96·0	7·4	5·5	16·0	32·0	5·5	0·5	40,673	1594
Farm labourer (Wales)	224·0	138·7	·5	5·9	10·0	85·0	9·8	0·5	48,354	2031
Farm labourer (Scotland)	204·0	204·0	5·8	4·0	10·3	124·8	2·5	0·7	48,980	2348
Farm labourer (Ireland)	326·4	92·0	4·8	1·3	4·5	135·0	—	0·3	43,366	2434
Mean of all	184·2	78·1	8·0	4·5	10·7	42·9	3·1	0·6	34,167	1500
Average per day	26·3	11·1	1·1	0·6	1·5	6·1	0·4	0·1	4,881	214

Daily Dietaries of Well-fed Operatives (Playfair).

Class of Labourer.	Flesh-formers.	Fats.	Starch and Sugar.	Containing		Containing	
				Carbonaceous.	Nitrogenous.	Carbon.	Nitrogen.
	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Grs.	Grs.
Fully fed tailors .	4·61	1·37	18·47	21·64	4·61	5136	325
Soldiers in peace .	4·22	1·85	18·69	22·06	4·22	5246	297
Royal Engineers (work) . . .	5·08	2·91	22·22	29·38	5·08	6494	358
Soldiers in war .	5·41	2·41	17·92	23·48	5·41	5561	381
English sailor. .	5·00	2·57	14·39	20·40	5·00	4834	252
French sailor . .	5·74	1·32	23·60	26·70	5·74	6379	405
Hard-worked weavers . .	5·33	1·53	21·89	25·42	5·33	6020	375
English navvy (Crimea) . .	5·73	3·27	18·21	21·06	5·73	5014	404
English navvy (Railway) . .	6·84	3·82	27·81	37·08	6·84	8295	482
Blacksmiths . .	6·20	2·50	23·50	29·50	6·20	6864	437
Prize-fighters (training) . .	9·80	3·10	3·27	10·70	9·80	4366	690
Mean of all . .	5·81	2·42	18·63	24·31	5·81	5837	400
Mean of low-fed operatives .	3·04	0·64	21·18	22·78	3·04	4881	214

As an addendum to these data, and by way of contrast, I may here give some particulars with reference to the dietaries of the convicts confined in English prisons. In the hard-labour prisons, where the great majority of the prisoners are employed at active outdoor work, there are two scales of diet—viz. the light-labour diet, and the full-labour diet. When medical officer to the Portsmouth Convict Prison, I carefully calculated the nutritive values of the various articles of food contained in these diets, according to the equivalents given in a preceding table, and the results were as follows:—

	Daily Average.	
	Carbon. Grs.	Nitrogen. Grs.
Light-labour diet	4651	224
Full-labour diet.	5289	255

What is called light labour applies to manual work requiring very little muscular exertion, while full labour embraces a variety of occupations, such as tailoring, shoemaking, artisan work, and navvy work. From the averages already given, it will be inferred that the light-labour diet was quite sufficient for the easy nature of the work, and, practically, with few exceptions, this was found to be the case. The prisoners employed at light labour were all more or less invalid or crippled, and although almost all of them could have taken more food, they were not found to lose weight, except in isolated cases. With regard to the practical working of the full-labour diet, however, this much could not be said; for while prisoners employed at comparatively easy labour, such as artisan work, did not lose weight to any extent, those employed at the more arduous kinds of labour, such as navvy work, almost invariably lost a great deal, and after a time had to be removed to lighter work to recruit. In whole gangs of prisoners employed at filling and wheeling barrows of clay, for example, I found an average loss of weight of over 13 lbs. per prisoner, the loss accruing within a period of about two months after they had been put to such work. The consequence was that the convicts had to be continuously shifted from hard to lighter work, and, after recruiting, from lighter to hard, otherwise they would have completely broken down, on account of the insufficiency of the full-labour diet for the severer kinds of prison labour. In military prisons, according to Dr. Letheby, where the dietary contains as much as 5090 grains of carbon and 256 grains of nitrogen daily, even for short periods of confinement, many of the prisoners lose weight, and give evidence of other signs of decay, so that it is found necessary to increase the diet for longer periods to 6362 grains of carbon and 317 of nitrogen. Of course military prisoners require more food than convicts, independently of the nature of the work at which they may be employed, inasmuch as they are larger men, and the ordinary physiological wants of the body demand a proportionately greater amount of nutriment. But the difference in stature between the two classes of prisoners does not account for such a difference in diets, and I have no doubt that convicts employed at active outdoor labour would require at least as much as is represented by the average diet for ordinary labour given by Dr. Letheby—viz. a diet containing 5688 grains of carbon and 307 grains of nitrogen daily, to maintain them in good health, and prevent serious loss of weight.

That the above experiments and others which were subsequently carried out clearly established the insufficiency of the prison dietary for hard labour is borne out by the fact that the diet in public works' prisons has lately been increased, but to what extent I am unable to say.

SECTION IV.—CONSTRUCTION OF DIETARIES.

By reference to the numerous data already given, it will not only be easy to calculate the nutritive value of any given dietary, but a reliable opinion may be formed as to its suitability as well as sufficiency under specified circumstances. It now remains to point out the more important principles which ought always to be kept in view in the construction of dietaries; and, apart from the influence of work, which has already been considered, they may be briefly summarised as follows :—

1. *Influence of Sex.*—In the case of in-door operatives, the dietaries of women should be about one-tenth less than those of men.

2. *Influence of Age.*—Up to nine years of age, a child should be dieted chiefly on milk and farinaceous substances. At ten years of age it will require half as

much nutriment as a woman; and at fourteen quite as much as a woman. Young men who have not reached their full growth, but who are doing the same amount of work as adult men, require more food than the latter.

3. *Selection of Food.*—This embraces a variety of considerations, such as—

(1.) *The relative proportions of proximate constituents.*—These have already been shown in Moleschott's numbers, and they correspond very closely with those given by Dr. Letheby—viz. 22 of nitrogenous substances, 9 of fat, and 69 of starch and sugar. Whether the diet be mixed or purely vegetable the same proportions hold good, and the results of experience prove that they are substantially correct. For example, articles of food which are deficient in one class of constituents, are invariably associated with others which contain an excess of them. Thus we have butter, or milk, or cheese, with bread; bacon, with veal, liver, and fowl; melted butter or oil, with fish; and so on. Such combinations are also of great service in aiding the digestibility of food. For reasons to be afterwards stated, every dietary should contain fresh vegetables.

(2.) *Variety of Food.*—But even when the proper proportions of constituents are provided for in a dietary, it is further necessary that certain articles belonging to the same class be varied from day to day, otherwise the appetite cloys. Beef should alternate with mutton, for example; or variety may be secured by different modes of cooking the same article. Indeed, it is not too much to say that the art of cookery is a matter of national importance, not only because it renders food palatable, but because the more it is studied and practised the greater is the economy which may be effected. It is chiefly in this respect that beverages, condiments, etc., become such valuable dietetic adjuncts.

(3.) *Digestibility.*—This also in great measure depends upon the mode of cooking.

(4.) *Price.*—For much practical information on this and other points, see Dr. Edward Smith's *Practical Dietary,* or his report on the Food of the Lancashire Operatives, in the Fifth Report of the Medical Officer to the Privy Council.

4. *Number and Distribution of Meals.*—Experience teaches that three meals daily are best suited to the wants of the body. Dr. Edward Smith in his physiological diet of 4300 grains of carbon and 200 of nitrogen, distributes the amounts as follows :—

	Carbon. grs.	Nitrogen. grs.		Carbonaceous. oz.	Nitrogenous. oz.
For Breakfast . . .	1500	70	=	6·62	1·04
For Dinner	1800	90	=	7·85	1·34
For Supper	1000	40	=	4·52	0·59
Total daily . . .	4300	200		18·99	2·97

5. *Climate.*—Other things being equal, carbonaceous substances ought to contain a preponderance of fatty constituents in cold climates, and of starchy or farinaceous, in warm climates. This also applies to seasonal variations.

SECTION V.—PRESERVED FOODS.

Only a few of these need be mentioned.

1. *Liebig's Extract.*—This is more especially valuable to the traveller or the invalid. According to Dr. Parkes it is very restorative, removing all sense of fatigue after great exertion. Its nutritive qualities are inferior to those of ordinary beef-tea, but it can often be taken by an invalid when beef-tea would be rejected ; and it has the further advantage of being readily prepared.

2. *Preserved Meat.*—What is known as Australian meat has the most extensive sale. Weight for weight,

it is not so nutritious as properly cooked fresh meat, because the process of preservation requires that it should be over-cooked. The great difference in price, however, more than compensates for this slight disadvantage, and on the score of economy alone it deserves to be extensively used. Large quantities of it are now consumed in workhouses and asylums. It is best used cold, or warmed and mixed with potatoes and vegetables to form a stew; or it may be minced and warmed. In Dr. Williams' experiments in the Sussex County Asylum, the patients were allowed amounts equal to the uncooked fresh meat daily ration, with the result of a slight gain in weight in 13 of the 20 experimented on at the end of a month, the weight of the others remaining stationary.

3. *Preserved Vegetables.*—When fresh vegetables cannot be procured in sufficient quantity, dried vegetables should be employed to make up the deficiency. In lieu of potatoes in the early part of summer, preserved potatoes may be used, but as they are apt to pall on the appetite, other substitutes, such as a mess of rice and cabbage, pease-pudding, or haricot beans, should be given on alternate days.

4. *Preserved Milk.*—According to recent analyses conducted by Mr. Wanklyn, the condensed milk prepared by the Anglo-Swiss, Newnham's, and the English Condensed Milk, Companies, consists of pure milk sweetened with a little sugar. As one volume of the condensed milk contains the nutritive material of four volumes of fresh milk, it should be diluted with three times its volume of water when used.

SECTION VI.—EXAMINATION OF FOOD.

It need scarcely be said at the outset that a thorough practical knowledge of the qualities and appearances presented by the various articles of diet, in their wholesome or unadulterated state, is a necessary qualification for the detection of unwholesome or adulterated specimens.

1. *Meat.*—The characters of good meat may be enumerated as follows :—

(1.) On section it should present a marbled appearance from intermixture of streaks of fat with muscle. This shows that the animal has been well fed.

(2.) The colour of the muscle should neither be too pale nor too dark. If pale and moist, it indicates that the animal was young or diseased ; and if dark or livid, it shows that in all probability the animal was not slaughtered, but died with the blood in it.

(3.) Both muscle and fat should be firm to the touch, not moist or sodden, and the latter should be free from hæmorrhagic points.

(4.) Any juice exuding from the meat should be small in quantity, be of a reddish tint, and give a distinctly acid reaction to test-paper. Good meat should dry on the surface after standing a day or two. The juice of bad meat is alkaline or neutral.

(5.) The muscular fasciculi should not be large and coarse, nor should there be any mucilaginous or purulent-looking fluid to be detected in the intermuscular cellular tissue.

(6.) The odour should be slight, and not by any means disagreeable. An unpleasant odour indicates commencing putrefactive change, or that the meat is diseased. By chopping a portion of the meat into small pieces, and afterwards drenching it with warm water, any unpleasantness of odour will be more readily detected.. Another good plan is to thrust a long clean knife into the flesh, and smell it after withdrawal.

If the meat is at all suspicious, the muscular fibre should be examined under the microscope. The smaller *cysticerci* and *trichinæ* can only be detected in this way. The brain and liver should also be examined for hydatids, the lungs for multiple abscesses, and the ribs for pleuritic adhesions. To detect cattle-plague, the mouth, stomach, and intestines should be examined.

Bad meat is usually sodden and flabby, with the fat dirty or gelatinous-looking, and the smell unpleasant or sickly.

I may here mention that it is the practice in the City of London to condemn the flesh of all animals infected with parasitic disease, such as measles, flukes, etc.; of animals that may have been suffering from acute, febrile, or wasting diseases; and of those which have died from natural causes or by accident; as well as all meat tainted by physic, or in a high state of putrefaction. It is also the practice to condemn the flesh of any animal which has been killed immediately before, during, or immediately after parturition, on the presumable grounds that an animal would not be slaughtered under such circumstances unless, from some cause or other, death appeared to be impending. A case of this description was tried at Lincoln, in March 1873, which I quote here as a case in point:—It appears that on a certain farm a sheep was killed by the shepherd, because, as he said, it was unable to lamb from excess of fat, and was ill in consequence. The carcase was dressed and sold to the defendants at a low price, but when exposed for sale was seized and condemned as unfit for food. On the evidence of Dr. Tidy, who was called as a skilled witness, the defendants were sentenced to pay a fine with costs, or be imprisoned for one month. I may here state that in similar cases brought before the magistrates in my own district, I have always succeeded in obtaining a conviction.

Bad-smelling sausages, or sausages which have a nauseous or putrid taste, a very acid reaction, or a soft consistence in the interior, are highly dangerous, and should always be condemned. So too with fish which has become sodden or discoloured, and gives off an offensive or ammoniacal odour.

It may here be noted that in apportioning rations of meat, 20 per cent must be allowed for bone. The loss in weight by cooking varies from 20 to 30 per cent.

2. *Flour.*—What is called good household flour or "seconds" should contain very little bran, be quite white, or only slightly tinged with yellow, and should give no acidity or musty flavour to the taste. It should not be lumpy or gritty to the touch, nor should it yield any odour of mouldiness to the sense of smell. When made into a paste with a little water, the dough should be coherent and stringy.

The amount of gluten can be ascertained by washing carefully a known quantity of flour, made first into a rather stiff dough, until the water comes off quite clear. The gluten, when baked or dried, should be clean-looking, and should weigh at least 8 per cent of the quantity of flour taken for examination. A good flour will yield 10 to 12 per cent. Bad flour gives a dirty-looking gluten, which is deficient in cohesion, and cannot be drawn out into long threads.

Flour is sometimes adulterated with barley-meal, maize, rice, potato-starch, etc. Samples of doubtful quality should therefore be examined microscopically. *Fungi*, *vibriones*, and the *Acarus farinæ*, are detected in flour which is undergoing putrefactive change.

3. *Bread.*—The crust should be well baked, not burnt. The crumbs should not be flaky or sodden, but regularly permeated with small cavities. The taste and smell should both be agreeable, and free from acidity. Unless there is a considerable quantity of bran in the flour, the colour should be white, not dark or dirty-looking.

Good flour, well baked, yields about 136 lbs. of bread per 100 lbs. of flour, and adulteration is chiefly directed to increase this ratio by making the gluten hard, and the bread more retentive of water. This the dishonest tradesman effects by adding alum, copper sulphate, or a gummy mixture of ground rice. The bread may be recognised by its becoming sodden and doughy at the base after standing for some time.

4. *Oatmeal.*—Good oatmeal is generally roughly ground, and contains a fair proportion of envelope freed from the husks. If husks are present, the probability is that the meal has been adulterated with barley. The starch should not be discoloured, and the meal itself should be agreeable to the palate. If the meal looks suspicious it should be examined microscopically.

5. *Milk.*—Pure cow's milk, when placed in a tall narrow glass vessel, should be perfectly opaque, of a full white colour, free from deposit, and should yield from 6 to 12 per cent of cream by volume. As it is frequently adulterated with water, the specific gravity is a fair test o the quality, and hence the value of the lactometer. The specific gravity varies from 1028 to 1032; if it falls below 1026 it shows that the milk is either very poor or that a certain amount of water has been added. The following table by Dr. Letheby indicates approximately the amount of water adulteration according to the specific gravity and percentage of cream:—

	Specific Gravity.	Percentage volume of cream.	Specific Gravit when skimme
Genuine milk	1030	12·0	1032
Do. with 10 per cent water.	1027	10·5	1029
Do. ,, 20 ,, ,,	1024	8·5	1026
Do. ,, 30 ,, ,,	1021	6·0	1023
Do. ,, 40 ,, ,,	1018	5·0	1019
Do. ,, 50 ,, ,,	1015	4·5	1016

When milk is largely adulterated with water, othe substances, such as treacle, salt, and turmeric, are some times added to improve the flavour and appearance; but, generally speaking, the use of a graduated glass vessel to determine the percentage of cream, and testing by the lactometer, will enable one to give a reliable opinion as to whether the milk is genuine or not. Suspicious samples should be sent to the public analyst for analysis.

6. *Butter.*—Butter should give no unpleasant or rancid taste. Adulteration with water or animal fats is best detected by melting the butter in a test-tube; the water, salt, or other substances remaining at the bottom. After separation of the casein by melting, good butter is entirely soluble in ether at 65° Fahr., while the fat of beef or mutton dissolves with great difficulty, and leaves a deposit. Adulteration with potato or other starch can be at once detected by iodine. Good butter, when melted, should yield a clear-looking oil, with little deposit of water or other substance.

7. *Cheese.*—The quality of cheese is determined by the taste and consistence. Inferior cheeses are often soft and leathery, owing to the amount of water which they contain. Starch, which is sometimes added to increase the weight, may be detected by iodine.

8. *Eggs.*—An average-sized egg weighs about 2 oz. avoir. Fresh eggs, when looked through, are more transparent at the centre; stale ones, at the top. In a solution of 1 of salt to 10 of water, good eggs sink, while the stale ones float.

9. *Potatoes* should be of good size, give no evidence of disease, be firm to the touch, and, when cooked, should not be close or watery.

10. *Tea.*—According to Dr. Letheby, the *bloom* or *glaze* of black and green tea is generally artificial. In the case of black tea, it sometimes consists of a coating of black-lead; and in that of green tea, it is usually a mixture of Prussian blue, turmeric, and China clay.

Both kinds of adulteration are detected by shaking the leaves in cold water, straining through muslin, and afterwards examining the deposit. Inferior mixtures, such as Maloo mixture, Moning congou, Pekoe siftings, etc., are largely imported into this country, and consist of exhausted tea-leaves, leaves of other plants, iron-filings, etc., with only a little good tea.

Good tea should yield a pleasant aroma, alike in the dry state and when infused in boiling water, and the flavour of the infusion should be agreeable. If the tea is suspicious, the infused leaves should be spread out and carefully scrutinised, and any powdery deposit examined under the microscope.

11. *Coffee.*—The principal adulteration of coffee is chicory. The adulteration may be detected either by microscopic examination or by sprinkling a portion of the suspected sample on the surface of water, when the coffee will float and the chicory sink. The presence of chicory is also indicated, if, on opening a packet of coffee, the contents are found to be caked, or show any signs of caking.

Amongst other articles of food or drink which are liable to adulteration may be mentioned cocoa, mustard, pepper, confections, beer, wine, and spirits; but without entering farther into this part of the subject, it will be sufficient to point out that any article of food or drink, or any drug which is supposed to be adulterated, should be submitted to a public analyst, on whose report proceedings may be taken under the provisions of the "Sale of Food and Drugs Act, 1875."

SECTION VII.—THE EFFECTS OF INSUFFICIENT OR UNWHOLESOME FOOD ON PUBLIC HEALTH.

1. The minor effects of insufficient food are generally so intimately associated with those of other causes of

disease, that it is impossible to estimate, with any approach to accuracy, their separate influence on public health. For, as Mr. Simon eloquently observes, "Long before insufficiency of diet becomes a matter of hygienic concern, —long before the physiologist would think of counting the grains of nitrogen and carbon which intervene between death and starvation,—the household will have been utterly destitute of material comfort; clothing and fuel will have been even scantier than food; against inclemencies of weather there will have been no adequate protection; dwelling-space will have been stinted to the degree in which overcrowding produces or increases disease; of household utensils and furniture there will have been scarcely any,—even cleanliness will have been costly or difficult; and if there still be respectful endeavours to maintain it, every such endeavour will represent additional pangs of hunger. The home, too, will be where shelter can be cheapest bought,—in quarters where there is commonly least fruit of sanitary supervision, least drainage, least scavenging, least suppression of public nuisances, least, or worst, water-supply, and, if in town, least light and air. Such are the sanitary dangers to which poverty is almost certainly exposed, when it is poverty enough to imply scantiness of food." And this picture, dark though it may appear, represents the condition of thousands who are struggling hard for very existence, and yet are all the while unsolicitous of relief. But when to these are added the numbers that swell the pauper list, and crowd the workhouses, with the famishing and permanently disabled, some conception may be formed of the wide-spread suffering and disease which follow in the wake of actual want.

The symptoms of failing health produced by insufficient diet, as observed in individual cases, are somewhat as follows:—There is gradual loss of flesh, advancing to extreme emaciation. The pulse becomes feeble, and the rancid oil, putrid blubber, and stinking offal; and in t country game is not considered to be in a fit state for t epicure's table until it is undergoing rapid putrefacti change. Admitting all this, however, there is abund evidence to prove that serious consequences resulting fr the use of unsound meat are of frequent occurrence, a in all probability a large proportion of cases of obsc disease owe their origin to the same cause. Moreover, is but only logical to conclude, from general principl that, as all diseases must affect the composition of ani flesh, and as active putrefactive change must at all eve deteriorate its nutritive value, it is of the utmost impo ance to health that these substances should be obtai in as sound a condition as possible.

The following is a brief abstract of the more impo ant facts connected with this part of the subject:—

(1.) *Putrid Meat.*—On the whole, this may be s to be wasteful rather than positively injurious, but th are numerous cases recorded in which it has produ serious disease. Vomiting, diarrhœa, and low fever o typhoidal type, are the chief symptoms. Putrid sausa are especially dangerous. According to an official retu it appears that in Wurtemberg alone, during the fifty years, there have been 400 cases of poisoning fr German sausages, and of these 140 were fatal.

(2.) *Diseased Meat.*—Here, again, the evidence of the same conflicting character. According to Letheby, enormous quantities of the flesh of anim that died of rinderpest in 1863, and more recentl pleuro-pneumonia, have been sent to the London mar sold, and eaten, without having produced any tang ill effects. It is also well known that Scotch sheph indulge largely in *braxy*, or diseased mutton, with parent impunity: and, according to M. Decroix, whole of the inhabitants of Paris would have suffe during the late siege if diseased meat were to any extent dangerous.

In the face of such evidence as this, it really becomes a question of public importance whether the flesh of *all* animals that have died diseased should be condemned. As a matter of fact, about one-fifth of the meat in the London market, according to Professor Gamgee, is of this description, and it is quite possible that, if it were sold under its true character, and proper precautions were taken with regard to selection and cooking, the ill effects which sometimes attend its use might not occur. Of course such meat would be of inferior quality, but being so, it would be much cheaper, and within the reach of many who are sorely in want of animal flesh, but cannot buy it at its present price. As it is, however, the butcher sells it under a fictitious character, and it is therefore the duty of the health officer to condemn it.

In the numerous cases of illness which have been attributed to the use of diseased meat, the symptoms are very similar to those occasioned by the use of putrid meat. The exceptional symptoms apply chiefly to the development of parasitic disease. Thus, the *Cysticercus cellulosus* of the pig produces the *Tænia solium*, and that of the ox or cow, the *Tænia medio-canellata*. The *trichina* disease, again, which a few years ago was so prevalent in many parts of Germany and elsewhere, is due to the *Trichina spiralis* in pork; and the *ecchinoccus disease* owes its origin to the flesh of sheep and cattle which have become diseased by the tænia of the dog. It appears that all these parasites are destroyed if the meat is thoroughly cooked before being eaten.

(3.) Some kinds of fish, especially in warm weather and in hot climates, have been known to produce very severe symptoms. Thus cases of acute urticaria with swelling of the tongue, fauces, and eyelids, are frequently due to eating lobsters, crabs, or shell-fish; while gastro-intestinal irritation, sometimes of almost choleraic intensity, is by no means a rare consequence of eating putrid fish of any kind. The disease known by the Spanish name of *siguatera* is of this description, and is common amongst the crews of vessels doing duty in the tropics when they partake of fish caught at the various stations as a change from the ordinary diet of the ship.

(4.) As regards unwholesome vegetable food, it may be said that all food of this description which has become mouldy is dangerous. On the Continent, the ergot of rye has been productive of serious epidemics, and in this country alarming symptoms have frequently followed the use of flour which contains the ground seeds of *Lolium temulentum*, or darnel.

In connection with the subject of unsound food, some special notice should be taken of the spread of disease through the agency of milk. And, first, it has to be noted that the milk of animals suffering from disease, as from foot-and mouth disease, though no doubt frequently used with impunity, sometimes produces aphthous ulceration of the mouth and gums, with swelling of the tongue, and great fœtor of the breath. Dr. Thorne reports an outbreak of this nature (see *Twelfth Report of the Medica Officer of Privy Council*), and I have myself witnessed a few well-marked cases of this description. It would also appear from a report presented to the Local Governmen Board by Mr. Power that there are strong grounds fo believing that diphtheria may be induced by the agency of milk. An outbreak of this disease occurred in North London in 1878 when Mr. Power found that out of 284 persons who were attacked, by far the greatest numbe received their milk-supply from two farms belonging to the same individual. He was unable to discover that the milk had actually been infected with the specific virus o diphtheria, and he was therefore driven to the conjecture that what he called "cow conditions" had been largely concerned in the epidemic; in other words, he believed that garget, a disease which affects the udder of the cow, could so change the character of the milk that the drinking of it induced diphtheria in the human subject.—(*Sanitary Record.* 1879.) In opposition to this view, however, I have the authority of Dr. Thursfield, medical officer of health for the Shropshire Combined Sanitary Districts, for stating that, after an extended experience of both these diseases, he has never been able to discover any such intimate connection between them.

Although it may be quite true, therefore, that the milk of diseased cows has often been used without producing any appreciable ill-effects, still there is always a certain amount of risk, and on that account it cannot be too strongly insisted on that all milk of the kind, or indeed any milk yielded by a cow suffering from any form of disease, should be condemned as unfit for human food. In the Western States of America the milk of cows affected with "the trembles," believed to be produced by feeding on *Rhus toxicodendron*, has frequently been known to cause severe gastric symptoms amongst children, accompanied by great weakness and lowering of the temperature (see *Medical Times and Gazette.* 1868). In this country very strong fears have likewise been expressed by the opponents to schemes of sewage irrigation, that the milk of cows fed on sewaged grass would be unwholesome and the butter become putrid. But, so far as I am aware, there is no well-authenticated instance of disease having been produced in this way, while I can assert to the contrary that there are large quantities of milk sold daily in and around Leamington obtained from cows fed exclusively on sewaged grass during the summer, and that on every occasion on which samples of the milk have been analysed, it has been found to be richly flavoured and of excellent quality. It may also be noted that several analysts have made repeated experiments with the butter, and have found that it possesses none of those tendencies to putrefactive change which have been so gratuitously attributed to it.

But the great danger attaching to milk, as a carrier of disease, depends upon its remarkable powers of absorption and the rapid fermentive or zymotic changes which it undergoes when it becomes mixed with putrefying matter, or tainted with disease-germs. Some few years ago it was proved by Mr. Lawson Tait, and the experiment has since been repeated by others, that milk exposed to the vapour of carbolic acid, for example, will very soon taste strongly of the acid; and in like manner, if it be kept in any close or badly ventilated place, where foul odours are perceptible, it will very soon become tainted and unfit for use. Very probably, it is in this way that such fungi as the *Oidium lactis*, described by Fuchs, Mosler, and Hessling are generated, and it is well known that milk so affected has frequently been the cause of gastric irritation and sharp attacks of vomiting. Moreover, there can be no doubt that much of the infantile diarrhœa, which proves specially fatal during the summer and autumn months, is due to milk, which either becomes tainted in this way, or becomes tainted by being put into feeding-bottles which are seldom or never properly cleaned. Indeed, there are so many unseen dangers in the use of milk, especially amongst careless and filthy people, that, to insure safety, it should always be boiled during warm weather, and particularly in districts where foot-and-mouth disease is prevalent. Milk should never be stored in sculleries or larders, or in vessels made of lead or zinc; in the latter case it speedily absorbs salts of the metal and becomes poisonous.

As regards the spread of specific disease, there is now an overwhelming amount of evidence which proves, beyond dispute, that milk is largely instrumental in propagating scarlatina and enteric fever; and amongst other instances may be mentioned the following:—The late Professor Bell of St. Andrews has related an outbreak of scarlet fever in that town, which showed very conclusively that the fever was distributed by the milk-carrier, or, what is more probable, that the diseased cuticle from the woman and children who vended the milk actually passed into it, and that in this way the poison was introduced.—(*Lancet*, 1870.) Again, Dr. Taylor of Penrith gives an account of a somewhat similar outbreak, in the *British Medical Journal*, 1870, where he also reports a group of cases of enteric fever which he believed to be due to specifically infected milk. Further, Dr. Ballard (*Lancet*, 1870) records an outbreak of enteric fever in Islington, which he attributed to the washing of the milk-cans with water derived from a tank which was found to communicate with two old drains, and one of these with the pipe of a water-closet. Whether the milk was adulterated with the same water was not ascertained, but the evidence, both positive and negative, rendered it tolerably certain that the disease was propagated in this way. These outbreaks were the first of the kind which were thoroughly investigated, but since then several others have been reported; as, for example, the outbreak at Armley, a village near Leeds, investigated by Dr. Robinson and Dr. Ballard in 1872; an outbreak at East Molesey, near Birmingham, also investigated by Dr. Ballard in 1873; an outbreak at Parkhead, a suburb of Glasgow, investigated by Dr. Russell in 1873; and the well-known outbreak at Marylebone, London, the real cause of which was, in the first instance, suspected by the late Dr. Murchison and others, and was subsequently investigated in all its intricate bearings by Mr. Netten Radcliffe, assisted by Mr. Power. In this instance the disease appeared within a few weeks in as many as 123 families, of whom 106 obtained their milk from a new milk company; and Mr. Radcliffe proved with "a probability amounting for practical purposes to a certainty, that—

"(1.) The outbreak of enteric fever, which formed the subject of inquiry, was caused by milk infected with enteric fever material.

"(2.) That this came from a particular farm.

"(3.) That the water used for dairy purposes on this farm contained excremental matters from a patient suffering from enteric fever, immediately before and at the time of the outbreak."—(See Mr. Simon's *Reports*, New Series, No. II.)

Another remarkable outbreak which was investigated by Mr. Power, occurred at Eagley, near Bolton, in 1876. Early in that year, over 200 persons were attacked in and around Eagley with undoubted enteric fever, and within the space of a few weeks. It was found that those attacked, both in Eagley and in Little Bolton, derived their milk from a dairy farm belonging to a Mrs Kershaw, that the milk itself had been "impoverished," and that there was the strongest evidence to show tha it had been diluted with water impregnated with fæca matter. Whether or not this matter contained th specific virus of enteric fever was not made quite clea although it was ascertained that one of the men, whos excreta passed into the brook from which the water wa derived, had been suffering from diarrhœa.—(*Sanitar Record*, 1876.)

Among more recent outbreaks of milk-typhoid whic have been investigated by medical officers of health ma be mentioned the following:—an outbreak at Edinburg (1877); one at Barrowford (1877); one at Glasgo (1878); one at Perth (1878); one at Croydon (1878 one at Bristol (1878); and one at Dublin (1879). The too, as regards scarlet fever, in addition to the two outbreaks at St. Andrews and Penrith already referred to, there have also been recorded a very suspicious outbreak investigated by Dr. Buchanan, which occurred among the guests at a party held in the West End of London in June 1875, when it was shown to be highly probable that the cream had been infected; another recent outbreak at Glasgow, investigated by Dr. Russell; and one at Dundee in 1878, investigated by Dr. Pirie.—(*Sanitary Record*, 1879.)

Other serious outbreaks besides those already mentioned might be quoted, but these are sufficient to prove that milk is a far more frequent agent in the spread of disease than is generally suspected; and, for my own part, I am inclined to believe that many obscure cases of enteric fever, and much of the autumnal diarrhœa, which occur in rural districts, are due to polluted milk. Indeed, several scattered cases of enteric fever have come under my own notice, in which, although there was no evidence to show that the specific virus had been introduced, it was clear enough that the well was contaminated with sewage, and that the milk-cans had been washed with the polluted well-water, even if the milk itself had not been diluted with it.

It is to be hoped that the Code of Regulations recently issued by the Privy Council for the registration, inspection, and wholesome conditions of cow-sheds and dairies, will result in obviating many of the hidden dangers to our milk-supply, but it is much to be regretted that the duties enjoined by the order should not have been entrusted to Sanitary Authorities and their officers, instead of to the County Authorities and inspecting veterinary surgeons. As it is at present proposed to be carried out, there is too much reason to fear that it will be practically inoperative. (See Appendix.)

CHAPTER III.

AIR: ITS IMPURITIES, AND THEIR EFFECTS ON PUBLIC HEALTH.

SECTION I.—COMPOSITION.

PURE AIR, according to the numerous analyses of D Angus Smith, is composed of 20·99 per cent by volum of oxygen, ·033 per cent of carbonic acid, and the rest nitrogen, watery vapour, and traces of ammonia. Wit the exception of carbonic acid and aqueous vapour, th relative proportions of the other constituents remai tolerably constant throughout the globe. In this countr the amount of oxygen varies from 20·999 per cent in th sea air on the coast of Scotland, to 20·910 in Manchest during frost and fog, while the carbonic acid ranges fro ·03 to ·05 per cent. The following averages of analyse quoted from Dr. Smith's work on *Air and Rain*, represen the more important variations in the open-air percentag of carbonic acid:—

	Carbonic Aci in 100 parts. Averages.
Different parts of Scotland, and at various altitudes	·0336
Perth City and outskirts	·04136
Closer parts of Glasgow	·0539
Opener parts of Glasgow	·0461
Suburbs of Manchester	·0369
Streets of Manchester	·0403
Open places of London	·0301
Streets of London	·0341
Lake of Geneva (Saussure's analysis)	·0439

It also appears that the air of the highest mountains contains more carbonic acid, less oxygen, and less organic matter, than the air of plains, and that the quantity of oxygen is always sensibly diminished in the air of towns.

The amount of aqueous vapour fluctuates greatly, and is mainly influenced by temperature. At a given temperature air cannot contain more than a certain quantity of moisture in suspension, and when it has taken up this quantity it is said to be saturated. In general, the air contains from 50 to 75 per cent of the amount requisite for complete saturation, the average amount being about 1·46 in 100 parts. If the quantity be not within these limits, the air is either unpleasantly dry or moist.

The ammonia, which exists as carbonate, chloride, sulphate, or sulphide, is present only in very minute quantities, and does not exceed one part in a million parts of air.

In addition to these ingredients, ozone may perhaps be reckoned as a normal constituent, and spectroscopic analysis has shown that the salts of sodium are everywhere present in greater or less abundance.

SECTION II.—IMPURITIES IN AIR, AND THEIR EFFECTS ON PUBLIC HEALTH.

Preliminary Remarks.—Impurities in air may be roughly divided into suspended and gaseous matters. While the presence of suspended matters is rendered familiar to every one in the shining particles which become visible in the direct rays of the sun, the well-known demonstrations by Professor Tyndall with the electric light have shown, perhaps more forcibly than heretofore, their almost universal diffusion. Particles of silica and silicates, of calcium carbonates and phosphates, of iron salts, and, in short, of every chemical constituent of the soil, are lifted by the winds and carried hither and thither. In inhabited places, carbon particles, hairs, fibres of cotton, wool, and other fabrics, starch-cells, etc., are found in great abundance. From the vegetable world are wafted seeds and the *débris* of vegetation, as well as spores, germs, pollen, and volatile substances. In like manner, the animal kingdom supplies germs of vibriones, bacteriæ, and monads, and particles of decayed or decaying tissues, such as epithelium and pus cells.

The numerous gaseous matters which pass into the atmosphere, and render it impure, will be more conveniently noticed in the subsequent remarks concerning overcrowding, and the injurious effects of different trades and manufactures.

But there are other organic vapours arising from the decomposition of vegetable and animal products which merit special attention, as, for example, those contained in the air of marshes and sewers. The exact chemical composition of these vapours still remains a mystery. Equally obscure too is the nature of those organic substances which constitute the specific poisons of contagious diseases. Whether they consist of inconceivably minute particles of decaying matter, or of living microscopi germs; whether, in some instances, they are conveyed b epithelium and pus cells from the diseased to the healthy or are condensed with the watery vapour of the atmosphere, and thus disseminated;—all these are question which have yet to be satisfactorily answered. Certain is, that in a large proportion of cases the atmosphere made the vehicle of the contagium or morbific agen whatever its nature; and hence the paramount importanc of adopting such measures as will prevent contaminatio of the air; or at all events aid in dissipating or destro ing its more noxious impurities. It is true, some of th operations of Nature are in themselves calculated accomplish this end. Injurious gases become diffused, diluted, or decomposed; animal emanations are absorbed in the processes of vegetation; suspended matters are washed down by the rains, or fall by their own weight; while many organic substances are oxidised, and thus rendered innocuous. Were it not for these purifying agencies, which are in constant activity, sanitary measures would prove futile; and, indeed, they are only successful in so far as they approximate to the preventive and remedial means which Nature employs.

1. *Air vitiated by Respiration.*—The effete matters thrown off in respiration are carbonic acid, watery vapour, and certain undefined organic substances.

According to Dr. Carpenter, who has summarised the results obtained by various physiologists, an adult man, under ordinary circumstances, gives off 160 grs. of carbon per hour. In both sexes the amount increases up to about the thirtieth year, but beyond the eighth year the exhalation is greater in males than in females. Dr. Parkes has given the average amount of carbonic acid exhaled by an adult in the twenty-four hours as 16 cubic feet, or a little over ·6 cubic feet per hour.

The quantity of watery vapour thrown off by the skin and lungs varies according to the hygrometric condition of the atmosphere. It has been estimated at from 25 to 40 oz. in the 24 hours, and requires, on the average, 210 cubic feet of air per hour to retain it in a state of vapour.

The organic matter given off has never been accurately determined. It has a very fœtid smell, and is but slowly oxidised. It is believed to be molecular, and may be said to hang about a room like clouds of tobacco-smoke, and, like tobacco-smoke, the odour is difficult to be got rid of, even after free ventilation has been resorted to. It darkens sulphuric acid, and decolorises solutions of potassium permanganate. When drawn through pure water it renders it very offensive. It is certainly nitrogenous, and probably in combination with water, because hygroscopic substances absorb it most readily. According to Lemaire, Trautman, and others, it contains minute cellular bodies named "putrefaction-cells," which have been found to bear a close resemblance to the so-called bacteriform puncta which Dr. Macdonald of Netley has detected in foul water. In sick-rooms it is associated with pus-cells and other emanations of disease. As much as 46 per cent of organic matter has been found in plaster taken from the walls of a hospital ward in Paris.

As the ammonia, and more especially the albuminoid may be taken as an index of the amount of organic impurities contained in air collected at various places, the following summary of analyses, by Dr. Angus Smith, is instructive:—

Air obtained from	No. of Experiments.	Free Ammonia. Grains per Million cubic feet.	Albuminoid Ammonia. Grains per Million cubic feet.	Total Ammonia. Grains per Million cubit feet.
Innellan (on the banks of the Clyde) . . .	1	22·845	60·228	83·073
London	18	26·780	65·947	92·727
Glasgow	4	34·169	133·264	167·433
A bed-room . . .	3	44·305	104·118	148·423
A midden . . .	3	146·911	181·524	328·435

According to a report on the air of Glasgow by Dr Russell and Mr. Dunnachie, published in May 1879 nitrogen, as free and albuminoid ammonia, was found to be always in excess in the two centric stations of observation in the city, when compared with analysis made o the air collected at an excentric station, but it was als found that the amount of potential or albuminoid ammonia became much lower in the month of July, clearl showing, especially when the amount of sulphur is taken into account, that both forms of ammonia are "largely derivatives of the rapid combustion of fire applied to wood or coal." These experiments have been confirmed to a certain extent by those which have been carried on for some time back at the observatory of Mountsouris, in the neighbourhood of Paris, and serve to prove that the amount of ammonia cannot be relied on as an index of the insalubrity of air without taking into account the natural history of each sample.

Practically speaking, the amount of organic matter in air vitiated by respiration is found to increase as the carbonic acid increases. According to Dr. Parkes it becomes distinctly perceptible to the sense of smell when the carbonic acid, in an inhabited room, amounts to ·7 per 1000 cubic feet of air—a statement which has been frequently verified by other experimenters.

Briefly then, the changes produced in an occupied air-space by respiration and transpiration are the following:—The amount of oxygen is greatly lessened, the carbonic acid and watery vapour are largely increased, ammonia and organic matter are evolved, and suspended matter in the shape of low forms of cell-life and epithelium scales is thrown off.

The effects of breathing considerable quantities of carbonic acid in air otherwise pure have not yet been determined with sufficient accuracy. Dr. Angus Smith has found that 30 volumes per 1000 cubic feet of air produced great feebleness of the circulation, slowness of the heart's action, and quickened respiration, but he experienced no discomfort in a soda-water manufactory, where the amount was 2 per 1000 volumes. On the other hand, Pettenkofer and Voit found that no discomfort was experienced from long exposure when as much as 10 per 1000 volumes was present. In respired air, however, headache and vertigo are undoubtedly produced in many persons when the carbonic acid exceeds 1·5 per 1000 volumes, but probably this is as much due to the presence of organic effluvia, and the diminution in the quantity of oxygen, as to the increase in the amount of carbonic acid. Yet it must be borne in mind that even a small excess of carbonic acid interferes with healthy physiological action, inasmuch as it prevents the sufficient exhalation of the gas itself, and induces an undue accumulation of it in the blood. In like manner, the quantity of oxygen absorbed is lessened, and there is consequently a retardation of those oxidising processes which are requisite for the complete elimination of effete matters from the system. But while there is always an increase in the amount of carbonic acid, there is likewise, as already pointed out, a marked diminution in the quantity of oxygen in respired air. Thus, Dr. Angus Smith found that the percentage of oxygen in the open air of a suburb of Manchester amounted to 20·96; in a sitting room to 20·89; in the pit of a theatre, to 20·74; in the Court o Queen's Bench, to 20·65; and in the sumpt of a mine to 20·1400. It does not follow that, because pain o discomfort is not always experienced in a vitiated atmosphere, no harm has been done. The effects may be slowly and imperceptibly cumulative, but they are none the less injurious, and they are now recognised as being amongst the most potent and wide-spread of all the "predisposing causes" of disease.

Speedily fatal results, arising from overcrowding and the want of fresh air, are familiar to every student o medicine. Out of the 146 prisoners confined in th "Black-Hole of Calcutta," 123 died in one night; and i is significant that many of the survivors afterwards succumbed to "putrid fever." Nor have similar instance been wanting in this country. Of the 150 passenger that were shut up in the cabin of the Irish steamer *Londonderry*, with hatches battened down during a stormy night in 1848, 70 died before morning. No doubt, in these two catastrophes, the direct cause of death was asphyxia, but the fact that " putrid fever " attacked many of those who were carried out alive from the Black-Hole of Calcutta, showed that the fœtid exhalations to which they were exposed must have aided largely in destroying the lives of the immediate victims. Indeed, it is admitted by all physiologists that the re-breathing of fœtid matter thrown off by the skin and lungs, produces a kind of putrescence in the blood, in proportion to the amount inhaled and to the period of exposure to its influences. Of this species of poisoning the history of the " Black Assizes," in the sixteenth, seventeenth, and eighteenth centuries, furnishes many terrible examples. Jail, or typhus, fever, according to Dr. Murchison, was frequently generated *de novo* solely in consequence of the disastrous effects of overcrowding and deficient ventilation, and the disease thus generated often spread from the court-house where the prisoners were tried, to the surrounding population. " My reader," said John Howard, " will judge of the malignity of the air in gaols, when I assure him that my clothes were, in my first journeys, so offensive, that in a post-chaise I could not bear the windows drawn up, and was therefore often obliged to travel on horseback. The leaves of my memorandum book were often so tainted that I could not use it until after spreading it an hour or two before the fire." Even so late as 1815, Harty showed that typhus was being constantly generated in the prisons of Dublin whenever they became overcrowded with convicts prior to the periodical transportation of the accumulated numbers to a penal settlement. Or, to come to more recent times, one finds Dr. Buchanan reporting to the medical officer of the Privy Council regarding an extensive epidemic in Merthyr-Tydfil in the beginning of 1870, that it was true typhus fever, and that he referred it to overcrowding, and to want of ventilation in the houses of the poorer people.

Such are some of the more direct and palpable effects of overcrowding and deficient ventilation; but there are others, perhaps equally grave, though not so well pronounced, which cannot be overlooked. All the so called zymotic diseases, for example, are more specially fatal, and spread with the greatest virulence, in densely populated and badly ventilated districts, and it is in these "fever-nests" that epidemic diseases, which prevail during certain septic conditions of the atmosphere, are attended with the highest mortality and the greatest sick-rate.

Of other diseases developed by respired air, there can be no question that phthisis pulmonalis holds a prominent place on the list. A large mass of evidence has been collected from various sources bearing on this point, but the fact is now so fully recognised by the medical profession generally that a few instances will suffice. In the celebrated report of the Army Sanitary Commission, published in 1858, it was proved beyond all doubt that the excessive mortality from consumption amongst soldiers, and in particular regiments, was due to overcrowding and insufficient ventilation. Previous to that inquiry the cubic space per soldier in the barracks of the Foot Guards only amounted to 331 cubic feet, and the phthisis mortality was as high as 13·8 per 1000. In the Horse Guards, on the other hand, with a space per man of 572 cubic feet, the mortality from phthisis did not exceed 7·3 per 1000. It was found that phthisis prevailed at all stations, and in the most varied and healthy climates, the vitiated air in the barracks being the only condition common to all of them. In consequence of this excessive mortality, the Commissioners recommended that the cubic space allowed per man in barracks should be increased, and the ventilation improved, with the result that, from the time their recommendations were acted upon, the number of phthisical cases occurring at all these stations has materially diminished. Similar evidence is afforded by the statistics of the Royal Navy, and notably as regards the civil population, in the Report of the Health of Towns Commission, published in 1844. Indeed, it has been fully established that not only phthisis, but other lung affections, such as pneumonia and bronchitis, are generated to a large extent under like conditions, and the same may be said of such diseases as scrofula, and others of an adynamic type.

When air is vitiated by the exhalations of the sick, as in hospitals, there is a risk of gangrene and erysipelas spreading, especially in the surgical wards. The period of convalescence in many cases is retarded, and the mortality rate increased. Pus-cells and putrefying particles are thrown off from purulent discharges, and finding a suitable nidus elsewhere, may communicate a special disease, and thus act as a true contagium. The prevalence of purulent ophthalmia, under certain conditions, and the spread of lung-disease in badly-ventilated ships, when the disease appeared to be propagated from person to person, can only be fully explained on some such theory as this. —(*Parkes.*)

2. *Air rendered Impure by Sewage and Cesspool Effluvia.* —Amongst the gases generated by the decomposition of fæcal matter, whether occurring in sewers or cesspools, may be enumerated, carbonic acid, nitrogen, sulphuretted hydrogen, light carburetted hydrogen, and ammonium sulphide. Dr. Letheby found that sewage-water, excluded from air, and containing 128 grs. of organic matter per gallon, yielded 1·2 cubic inches of gas per hour during a

period of nine weeks. But the amount of gaseous products given off under ordinary circumstances must vary greatly, according to the dilution of the sewage, the rapidity of flow, temperature, ventilation of the sewers, etc. In comparing the results of analyses made by various chemists, it would appear that the oxygen is diminished, and the carbonic acid greatly increased, but that sulphuretted hydrogen and ammonium sulphide, when present, exist only in very small quantities. The peculiarly fœtid smell of sewage-gas is therefore owing to the presence of organic matter, whose exact chemical composition, however, has not been determined. Dr. Odling believes it to be carbo-ammoniacal. It is alkaline in reaction, and speedily decolorises solutions of potassium permanganate. According to Dr. Cunningham, it contains distinct bacteria, and other low forms of cell-life. Like other organic effluvia, it promotes the growth of fungi infects milk, and taints meat.

It is doubtful whether the effects of sewer-air upon the health of men employed at work in sewers can be said to be very injurious. Indeed, the researches of Dr. Guy and Parent du Chatelet, at first sight, go to prove that this class of labourers enjoy a marked immunity from diseases which can be attributed to sewer-emanations; but, as has been shown by the late Dr. Murchison, there are several elements of error in their statistics which mar their conclusions. For example, Dr. Guy's researches were made before enteric and typhus fever were fully recognised as distinct diseases, and Parent du Chatelet's statistics were not only too scanty for a fair deduction, but the majority of the sewer-men whom he examined had been employed at that special work for only a short period. According to Dr. Murchison's experience, enteric fever is by no means uncommon among these men, and Dr. Peacock's inquiries led him to express a similar opinion. But whatever the issue of this question, it seems to be quite certain that constant exposure to sewer-gases diminishes the risk of being injured by them. A remarkable instance of this apparent immunity enjoyed by workmen, and the disastrous effects upon those whose exposure to such gases was only casual, is afforded by an event that occurred at Clapham in the autumn of 1829:—20 out of 22 boys at the same school were seized with violent vomiting, purging, prostration, and fever, within three hours. One boy had been seized with similar symptoms two days before, and died; another also succumbed. So alarming was the outbreak that poisoning was suspected, but, after careful investigation, it was found that the sole cause of disease was to be attributed to the opening of a drain at the back of the house. This drain had been choked up for many years, and had been opened two days before the first illness occurred. The effluvia from the drain were most offensive, and the boys had watched the workmen cleaning it out; none of the workmen, however, were subsequently attacked with any of the symptoms which so seriously affected the boys.—(*Murchison.*)

While numerous other instances are recorded of the evil effects of the air of sewers, cesspits, drains, etc., in producing temporary ailments, such as nausea, vomiting, diarrhœa, and headache, the great interest which attaches to this important subject rests on the development and spread of enteric fever. Without entering at present into the discussion as to whether this fever is purely specific, or may be generated *de novo*, there can be no question that the polluted air from cesspits, drains, and sewers, becomes the medium through which the disease is frequently propagated, if not engendered. The sewer-air, laden with *morbific ferments* or *contagia*, readily finds its way into houses, more especially in cold weather, on account of its greater tension, and in consequence c badly trapped or imperfectly ventilated drains. It ma be inappreciable to the senses, but its baneful effect make themselves felt none the less, and frequently exhib themselves in houses which in other respects are replet with every comfort which wealth can command. Indee it would appear that persons of the upper and midd ranks in towns are more liable to be attacked by enter fever than the poorer classes, and for this reason—tl houses of the former are more generally connected wit sewers, and, either from structure or situation, are higher elevation, so that the light sewer gases, in obed ence to natural laws, are more apt to accumulate in tl drains of such houses, and when the drains are n efficiently trapped or ventilated, to effect an entrance in the houses themselves. Thus it happens that a syste of sanitary engineering which is intended to prevent, a does prevent, the development of disease, not unfi quently furnishes the readiest means for its propagatic All this, however, could be frustrated if sewers and drai were always kept properly flushed and well ventilated.

Two other points connected with the propagati of enteric fever deserve notice: (1) it seems to be clea established that the disease may be contracted by i haling the effluvia from enteric stools previous to th being disposed of; and (2), that if these stools be thro into a common privy, the disease is almost certain to conveyed to others who frequent the privy; hence t necessity of disinfecting all discharges from the patient soon as they are passed. (For further remarks on tl subject, see Chap. XIV.)

Amongst other serious consequences of fæcal ema tions, the occasional spread of cholera, and the occurren of autumnal diarrhœa, are specially to be noted. T outbreak of cholera in the city of London Workhouse, July 1866, was shown by Mr. Radcliffe (*Ninth Report of Medical Officer of the Privy Council*) to have taken place, in all probability, in consequence of a sudden efflux of sewer-air from a drain containing choleraic evacuations. Autumnal diarrhœa, again, is found to prevail when the season is warm and dry, and more particularly in badly-sewered districts. In speaking of this subject, Dr. Murchison says, that " circumscribed autumnal epidemics of enteric fever are often preceded by an increase of diarrhœa, and the diarrhœa reaches its acme long before the fever does." After heavy falls of rain the sewers become well flushed, and the diarrhœa subsides. In country districts isolated outbreaks of diphtheria traceable to cesspool effluvia are not at all uncommon. In these cases it is generally found that there is a water-closet in the house which itself is badly ventilated, that the soil-pipe is never ventilated, and that the closet drain discharges into a cesspool which is completely covered up, and only cleaned out at rare intervals. The consequence is that any gases generated in the cesspool have no outlet except through the water-closet and into the house, and hence result attacks of diphtheria, ulcerated sore throat, and other badly defined ailments.

According to the evidence of Sir Henry de la Beche and Dr. Lyon Playfair, in the Second Report of the Health of Towns Commission, there are strong presumptive grounds for believing that emanations from streams polluted by fæcal matter may be injurious to the health of inhabitants living on their banks. It is stated that many of them were pale, and suffered from dyspepsia, and that cases of fever, when they occurred, were increased in severity. In other instances, however, no such effects have been traced.

When sewage matter is thrown over the ground, the exhalations given off have likewise been proved to be sometimes productive of serious disease. Thus, Dr Clouston has recorded an outbreak of dysentery among the patients in the Cumberland and Westmoreland Asylum which he attributed to the emanations from sewage applied to the land about 300 yards from the asylum. Afte this outbreak the sewage was allowed to fall into a smal stream, and for two years the asylum had been free from the disease. At the end of this period, however, th sewage was again applied to the farm, and again th dysentery appeared, although all proper precautions wer taken in the way of disinfecting and in applying th sewage. It is to be noted that there was a stiff brick clay subsoil, and doubtless this prevented the sufficien percolation of the sewage into the ground.

3. *Effluvia from decomposing Animal Matter.*—Unde this heading may be included—the effluvia from decomposing carcases; the air of graveyards; and the effluvi from manure, tallow, and bone-burning manufactories.

On almost all these points the evidence is very conflicting. The preponderance of opinion, however, leave no room for doubt that the effects of all such effluvia upo the health of the general population, when exposed to thei influence, are more or less injurious; and in support of thi view the following amongst many other confirmatory instances may be quoted:—

(1.) The effluvia arising from the putrid remains o horses killed on the field of battle have frequently give rise to outbreaks of diarrhœa and dysentery amongst th soldiers. In the French camp, before Sebastopol, whe numbers of the bodies of horses lay putrefying and unburied, the effects were so serious that the spread o typhus was supposed to be due to this cause.—(*Parkes.*)

(2.) According to the evidence summed up in th Report on Extramural Sepulture in 1850, the vapou given off from thickly crowded graveyards, if not actuall productive of disease, do certainly increase the sick and death rate of the immediate neighbourhood.

(3.) Although the health of workmen employed in manure and similar manufactories does not appear to be injured by their occupation, the occasionally disastrous effects upon others, of the effluvia given off, are well illustrated by the following case:—In 1847, many of the inmates of Christ Church Workhouse, Spitalfields, were seized with violent attacks of diarrhœa, of an enteric type. It was found that whenever the works were actively carried on, and particularly when the wind blew from that quarter, there ensued an outbreak of diarrhœa in the workhouse. In December of the following year, when cholera was spreading in the neighbourhood, sixty of the children were attacked one morning with violent diarrhœa. In consequence of this outbreak the owner of the manufactory was obliged to stop work, and the children rapidly recovered. Five months afterwards the works were resumed, and again there was a similar outbreak amongst the inmates occupying the part of the building opposite the manufactory. The works were once more discontinued, and the diarrhœa ceased.—(*Carpenter.*)

The effluvia produced in tallow-making and similar trades, though sometimes very offensive, and therefore an undoubted nuisance in inhabited districts, do not appear to have produced any serious effects which have been recorded. According to Dr. Ballard, however, they often induce headache, nausea, and sometimes diarrhœa. —(*Report of Med. Officer, Local Government Board,* 1876.)

4. *Gases and Vapours given off by Alkali Works, Chemical Works, and Brickfields.*—(1.) The principal gas evolved in alkali works is hydrochloric acid. Its effects on vegetation are very destructive, but with proper care in the condensation of the gas, there does not appear to be any evidence to show that works of this description

are injurious to the health of those living in the neighbourhood.

(2.) From chemical works, and especially from those in which gas liquor is utilised for the production of salts of ammonia and other chemical compounds, the injurious gases evolved consist chiefly of sulphuretted hydrogen, ammonium sulphide, and traces of other ammonium compounds. The workmen employed at such works apparently enjoy good health, but when the noxious vapours are not properly consumed by being collected and passed through a furnace, there is no doubt that they do affect the health of the neighbouring inhabitants, though not to any serious extent.

(3.) The peculiarly pungent odour of brickfields can be felt at several hundred yards' distance; but though several cases are recorded, in which the existence of a nuisance was fully established, none are quoted as having proved that the health of the neighbourhood was affected.

5. *The Air of Marshes.*—This generally contains an excess of carbonic acid, light carburetted hydrogen, watery vapour, sulphuretted hydrogen, and organic effluvia. It also abounds with the *débris* of vegetable matter, infusoriæ and insects.

The more serious and characteristic effects of mars miasmata are intermittent and remittent fevers. Ailments, however, of a less severe nature—such as diarrhœ dysentery, and various other gastric derangements—hav been attributed to their influence; and even when n marked signs of disease can be detected, the inhabitan of such districts often present an enfeebled and palli appearance. The submerging of meadows, draining lakes, and digging of canals, have all of them been fo lowed by the development of marsh diseases, probably o account of the decomposition of vegetable matter whi ensues. For the same reason, a long continuance of dr weather, followed by rains, favours the evolution of miasmata. Fortunately, in this country, marsh-diseases have become comparatively rare, though there is no doubt that in low-lying and badly-drained districts the excessive sick-rate which often prevails is in a great measure owing to atmospheric impurities of a marshy nature.

6. *Air-Impurities in certain Trades and Occupations.* —The deleterious impurities under this heading consist chiefly of mineral and organic substances, as, for example, the particles of coal-dust in the air of mines; particles of steel and grit given off in grinding; arsenical fumes, in copper-smelting; zinc fumes, in brassfounding; pearl-dust, in button-making; organic dust or fluff, in shoddy and flax mills, etc. But the whole of this part of the subject is so extensive, that only a few instances of the increased sick-rate and mortality produced by these impurities can be given here.

The habitual inhalation of coal-dust contained in the air of coal-mines results in what is called the "black-lung;" the pneumonic cells becoming gradually blocked up, so that, after death, the lung presents a peculiarly melanotic appearance. Cases of emphysema and chronic bronchitis are also very common amongst colliers, and it has been ascertained that the aggregate amount of sickness experienced by this class of workmen between the ages of 20 and 60 amounts to 95 weeks, or 67 per cent more than the general average.—(*Wynter.*) No doubt much of the disease with which miners are liable to be attacked is to be attributed to the baneful effects of inhaling the products of combustion given off by candles, lamps, etc.; because, when mines are well ventilated, as in Durham and Northumberland, lung affections are much less frequent.

But of all unhealthy occupations that of steel-grinders is perhaps the most fatal. Steel-grinding is divided into dry, wet, and mixed; the injurious effects varying according to the amount of water used on the stone. Forks, needles, backs of scissors, etc., are all ground on the dry stone, and, accordingly, the men and boys employed at this kind of work suffer most. Dr. Hall of Sheffield has collected a large amount of information bearing upon this subject, from which the following particulars relating to the average duration of life of artisans in steel have been summarised by Dr. Wynter:—"Dry-grinders of forks, 29 years; razors, 31 years; scissors, 32 years; edge-too and wool-shears, 32 years; spring-knives, 35 years; files 35 years; saws, 38 years; sickles, 38 years." Fans however, are now more commonly used than formerly, and wet-grinding is becoming more general, so that it is to be hoped the average longevity of Sheffield grinders is increasing.

In the pottery trade, the flat-pressers and scourer suffer to such an extent from the effects of the fine dus inhaled, that, according to Dr. Greenhow, almost all o them become eventually asthmatical.

Pearl-button makers, and workers in flax or shodd mills, are all afflicted more or less with bronchial irritation, and many of them with decided lung-disease Cotton-weavers also suffer very much from the fine dus given off by the "sizing;" and recently an inquiry wa made by Dr. Buchanan at Todmorden, which revealed th great prevalency of lung-disease, dyspepsia, and permanent epistaxis, amongst this class of operatives.

In addition to asthma and bronchitis, brassfounder are very liable to attacks of an affection called "brassfounders' ague," the characteristic symptoms of whic present themselves in the following sequence;—shivering nervous depression, marked febrile disturbance, and profus sweating. Flour millers, sweeps, and snuff-grinders, ar all of them apt to suffer from various forms of asthma.

Workers in lead are apt to suffer from "drooping wrist" and lead colic; lucifer-match makers, from necrosis of the lower jaw, caused by phosphorus fumes; and workers in mercury, from mercurialism.

In the Third Report of the Medical Officer of the Privy Council, Dr. Greenhow gives the following summary of his inquiry into the excessive mortality from lung-diseases:—

"This inquiry has demonstrated that an excessive prevalence of pulmonary diseases is associated with a great variety of conditions, some of which must clearly be regarded as exciting causes of these diseases. With respect to others, it has been found impossible to obtain accurate and conclusive evidence that they produce diseases of the lungs, but there are strong grounds for supposing such to be the case. There is also a third class of conditions, on which great stress was laid by various medical practitioners, and which may perhaps be regarded as having a tendency to produce these diseases. The conclusions deducible from the inquiry may therefore be arranged under the three following heads:—

"A. Conditions which this inquiry has shown to be direct causes of pulmonary diseases.

"B. Conditions so frequently associated with an excessive pressure of pulmonary diseases, that they may be regarded as at least indirect causes of these diseases.

"C. Conditions which, in all probability, co-operate in producing pulmonary diseases, but respecting the influence of which no conclusive evidence could be obtained."

"A. 1. Inhaling an atmosphere loaded with mechanical impurities, such as fine dust of metal, stone, clay, or of certain animal and vegetable products; soot, and particles of flax, cotton or woollen fibre, exemplified in the case of grinders of cutlery, needles, and other steel articles; miners, quarrymen, stonemasons, china-scourers, potters, turners of earthenware, makers of plaster-of-Paris moulds, hacklers of flax and Mexican fibre; sorters of wool, alpaca, and mohair; operatives employed in the manufacture of waste silk, and in the carding-rooms of cotton factories; wool-combers; workers in bone, ivory, horn, and mother-of-pearl; and makers of walking-sticks, and wooden handles for cutlery, umbrellas, and parasols.

"2. Inhaling an atmosphere containing carbonic acid, or other gases unfit for respiration, or fumes arising from the combustion of gunpowder, or of charcoal, or other fuel, as exemplified in the cases of miners and wool-combers.

"3. Inhaling an overheated and highly-dried atmosphere, exemplified in the cases of the flat-pressers, and some other workers in potteries.

"B. 1. Habitual exposure, during the hours of labour, to a hot and exceedingly moist atmosphere, exemplified in the cases of slip-makers in potteries and spinners of flax.

"2. Working in ill-ventilated and over-heated factory-rooms, as in many manufactories of textile fabrics, in some of the decorators' rooms of potteries, in warehouses, and likewise in many establishments where young females are congregated together at work.

"3. Exposure to vicissitudes of temperature, exemplified in the cases of the operatives in several kinds of factories and workshops.

"4. A stooping or otherwise constrained posture while at work, exemplified in lace-makers, throwers of earthenware, certain classes of weavers, file-cutters, and silk-piercers.

"5. Working continuously many hours daily at a sedentary occupation, such as that of the glove-makers of Yeovil, decorators of earthenware, and welters and finishers of hosiery.

"6. Working in ill-ventilated and overcrowded rooms, as in the straw-plat and lace schools of Berkhamstead, Towcester, and Newport Pagnell, the winding-rooms of Leek, and the weaving shops of Hinckley and Leicester.

"7. Residing in dwellings so constructed that the bedrooms are badly ventilated, and the cubical space per head is inadequate to the preservation of health, such as are to be found in Berkhamstead and Saffron Walden.

"C. 1. Bleakness of climate, a cold damp soil, prevalence of fogs.

"2. Marriages of consanguinity.

"3. Habitual abuse of alcoholic stimulants.

"4. Insufficiency of animal food."

Although certain parts of this summary have no immediate connection with the subject-matter in hand, it has been given *in extenso,* to show how frequently several causes of disease co-operate in producing the same pathological results, and how difficult it is to apportion to these causes their relative share in the combined effects. But, apart altogether from the unwholesome influences attaching to particular employments, the one great fact which stands forth with special prominence throughout the whole of Dr. Greenhow's inquiry (see also *Fourth Report to Privy Council*), is the fatally defective state of the ventilation, alike of cottage, workroom, and of busy factory. The mortality from lung-disease amongst male and female operatives was found to be from three to six times as great as in other districts in England; and in a very large proportion of cases the want of ventilation in dwelling-places, as well as work-places, prevailed to such an extent, that tubercular and scrofulous diseases must have resulted abundantly from this cause alone.

The medical officer of the Privy Council, in commenting on this inquiry, remarks—"One must remember that, in most cases, either the artisan's ill-ventilated work-place is also his ill-ventilated dwelling-place, or else the dwelling-place to which he goes for his rest is as ill-ventilated as the work-place which he leaves; that during a great part of the year the work-place has artificial light in it, in many cases gaslight for some hours of the day, and in some cases has its atmosphere vitiated by other products of combustion; that in factories during winter the commonly adopted method of warming is one which in itself makes the air unpleasant, if not hurtful for breathing; and that in many branches of industry good ventilation is essential as a safeguard against evils which are special to the employment—essential for the removal of injurious dust, or for the abatement of an oppressive temperature."

In all these industrial employments it thus appears that the sick-rate and death-rate could both be very materially lessened by promoting ventilation, and by introducing some suitable appliances calculated to protect the workmen from the inhalation of fine dust or noxious fumes. But it was found that the workmen themselves often objected to any innovation which appeared to them to interfere with their more immediate comfort; and not a few of them were under the impression that the introduction of any measures tending to prolong life would be followed by such an overstocking of the labour market, that the difficulties of procuring a living would be greatly increased. That such short-sightedness will continue to exist amongst certain numbers of the artisan class is only what may be expected. Disease sets in so insidiously and progresses so slowly, the stock of health to start with seems so ample, and the individual prospect of death so remote, that sanitary rights are neglected and the wrongs quietly endured. No doubt, these wide-spread evils have been greatly mitigated of late years under the provisions of the Factory and Workshops' Acts, but complaints l made by inspectors that the workmen continue ery careless about ventilation, and that they have aversion to using respirators, even when they know eir use is a safeguard against disease.

Germany, the whole of this subject has been very y studied by Dr. Hirt, to whose elaborate work, *ankheiten der Arbeiter,* I would refer all who are s of making themselves fully acquainted with in- trades and the diseases which they severally or are liable to induce, in those employed at them.

th respect to the effects of trade-nuisances on the health of the community, a very important inquiry ently been conducted by Dr. Ballard in behalf of al Government Board, which is of special interest ary authorities and their officers throughout the . Two instalments of Dr. Ballard's report have been published in the Supplements to the Local ment Board Reports, 1876 and 1877, and when ole has been completed, it will certainly rank as st valuable and exhaustive contribution which has appeared on the subject. The trades embraced inquiry included—(1), the keeping of animals; slaughtering of animals; (3), branches of industry ch animal substances are principally dealt with; des in which vegetable matters are principally ith; (5), trades in which mineral substances are ally dealt with; and (6), trades in which matters d origin are dealt with. According to Dr. Ballard, st offensive effluvia are those given off from trade es, in which the materials used consist of animal ces—such as gut scraping, manure manufacturing, e melting of some kinds of fat. The industries deal with vegetable substances, though often very ve, do not appear to give rise to effluvia which may ignated disgusting, and are therefore not so liable to be injurious; while those which treat mineral su stances are chiefly offensive owing to the irritant gas and other effluvia which are given off. As might expected, great difficulty was experienced in ascertainin with any approach to precision, in what respect, and what extent, these effluvia are injurious to health; but regards all of them, it has to be noted that in records proceedings of courts of law, and as the result of D Ballard's inquiries, the particular group of sympton generally complained of consisted of "loss of appetit nausea, sometimes actual vomiting, sometimes diarrhœ headache, giddiness, faintness, and a general sense depression and *malaise*." Concerning effects of a mor definite nature, Dr. Ballard points out that while trad effluvia generally contribute their quota of condition which render the air of manufacturing towns comparativel insalubrious, there are certain effluvia of septic origi connected with businesses of a specially filthy nature which are undoubtedly unwholesome, and give rise t filth diseases of various kinds. Other trades, again, i which matters are dealt with which are liable to b infected with specific contagia, cannot fail to be dangerou to persons exposed to such influence, while, as regard trades which give off effluvia consisting of definit chemical compounds, they are, as a rule, only irritating o injurious in proportion to their degree of concentratio It is often suggested by manufacturers, that because certai effluvia given off by chemical works are in common us as disinfecting agents, they must actually be beneficial t public health; but, as Dr. Ballard points out, this argument is altogether fallacious, inasmuch as such agents ar virtually inoperative, unless applied in a degree of concentration far greater than the diluted effluvia ofte complained of outside the works.

In other respects, Dr. Ballard's report is especiall valuable, because it points out in detail not only the trades or trade processes which are most complained of as offensive, but it explains the methods in use, or which may be devised, for preventing or minimising the nuisances arising from them. This part of the subject, however, will be more fully treated in Chap. XV.

CHAPTER IV.

VENTILATION AND WARMING.

THESE two subjects may be conveniently treated under the following sections:—

I. The Amount of Fresh Air required.
II. The Necessary Amount of Cubic Space.
III. Natural Ventilation.
IV. Artificial Ventilation and Warming.

SECTION I.—THE AMOUNT OF FRESH AIR REQUIRED.

As the air contained in an inhabited room cannot, under the most favourable circumstances, be maintained in as pure a condition as the external air, the object of ventilation is to reduce the impurities of respiration to such an extent that continued inhalation of them will not be detrimental to health. While this can only be effected by a constant supply of fresh air, it is evident that the quantity required will very much depend on the amount of impurities which may be allowed to accumulate in respired air without proving injurious. The first point, therefore, which has to be determined, is the limit of maximum impurity consistent with the maintenance of perfect health. It has already been shown that the amount of carbonic acid in air vitiated by respiration is a tolerably reliable index to the other impurities; and *hence* the question resolves itself into this,—What amount of carbonic acid shall be accepted as the standard of permissible maximum impurity? After numerous experiments, and a most extended inquiry, Dr. Parkes has given it as his opinion that, allowing ·4 volume as the average amount of carbonic acid in 1000 volumes of air, this standard ought not to exceed ·6 per 1000 volumes; because, when this ratio is exceeded, the organic impurities, as a rule, become perceptible to the senses. With a ratio of ·8, ·9, or 1 per 1000 volumes, the air smells stuffy and close, and beyond this it becomes foul and offensive. —(*Practical Hygiene.*)

Perhaps there is no class of buildings which present better opportunities for arriving at an approximate and practical solution of this problem than prisons; and it may prove of some service if I record briefly the results of some experiments which some time ago I had a share in conducting, and which are strongly corroborative of Dr. Parkes' views.—In one of the English convict prisons one-half the prisoners are kept in separate confinement, except when at exercise; the other half are confined in their cells only during the night and when at meals. The cubic space and ventilating arrangements in the part of the prison occupied by the former were such, that the average ratio of carbonic acid, after a series of observations made at different hours of the night, was found to be ·720 per 1000 volumes; while in the part of the prison occupied by the latter, the cubic space was much smaller, and the average amount of carbonic acid was as high as 1·044 per 1000 volumes. The same number of observations were made in both parts of the prison at the same hours during the night-time, so that a strictly fair comparison could be drawn. Now, a careful inspection of the two classes of prisoners resulted in showing that whereas the former were well-nourished and healthy-looking, the latter presented a somewhat less robust and more pallid appearance; and after eliminating every source of error, this difference in appearance could only be accounted for by the difference in the amount of impurities contained in the respired air of both parts of the prison.

I have had many other opportunities of examining into this point, and would say, in general, that when the carbonic acid does not exceed ·8 per 1000 volumes, no *tangible* injurious effects upon the health can be detected; but when it reaches 1 per 1000 volumes, the cumulative effects manifest themselves in producing a pallid dyspeptic appearance, and make themselves felt, in numerous instances, in general *malaise* of a morning, slightly coated tongue, nasty taste in the mouth, and headache.

The desirability of adopting Dr. Parkes' estimate a the standard of maximum impurity is also borne out by the observations and experiments of such eminent authorities as Professor Pettenkofer of Munich, Dr. Angus Smith, and Dr. de Chaumont. "We all avoid," says Dr. Smith, "an atmosphere containing ·1 per cent of carbonic acid in crowded rooms; and the experience of civilised men is, that it is not only odious but unwholesome. When people speak of good ventilation, they mean, without knowing it, air with less than ·07 per cent of carbonic acid. We must not conclude that because the quantity of carbonic acid is small, the effect is small; the conclusion is rather that minute changes in the amount of this gas are indications of occurrences of the highest importance.—(*Air and Rain.*)

Assuming, then, that ·6 carbonic acid per 1000 volumes is accepted as the standard of maximum impurity, the next question comes to be—How much fresh air must be supplied per head per hour, in order that the respired air should not contain impurities in excess of this standard? It has already been stated, in the previous chapter, that an adult man exhales on the average ·6 cubic foot of carbonic acid per hour, and taking the initial carbonic acid contained in the atmosphere at the normal ratio of ·4 per 1000 volumes, the quantity of fresh air which should be supplied is found by calculation to amount to 3000 cubic feet per head per hour, in all cases in which the diffusion of the contained air is uniform. Of course, if a standard not so pure is fixed upon, the amount of fresh air required would be proportionately less. Thus, supposing the limit of maximum impurity to be ·7 carbonic acid per 1000 volumes, the amount required would be 2000 cubic feet; if ·8, 1500 cubic feet; and ·9, it would be 1200 cubic feet per head per hour. It is evident also that women and children would require a smaller supply than men, because they do not vitiate the air so rapidly.

The results obtained by actual experiment accord so closely with those which have been deduced from mathematical calculation, that some of them may be fitly quoted here. The following are given by Dr. de Chaumont (*Edin. Med. Journal*, 1867) as selections from a series of observations made at Aldershot camp:—In a room containing 18 men, with a supply of 1200 cubic feet of fresh air per head per hour, the carbonic acid was found to be ·855 per 1000 volumes; in another containing 13 men, with a supply of about 1700 cubic feet, it was ·759 per 1000 volumes; and in a third, containing 22 men, and with a supply of about 765 cubic feet per head per hour, it amounted to 1·2 per 1000 volumes. All these observations were made at the same hour (5 A.M.), and in barrack-rooms ventilated on the plan proposed by the Barrack Commissioners in 1861, which provided that at least 1200 cubic feet of fresh air should be delivered per head per hour.

But there are other circumstances in which it is necessary to augment the delivery of fresh air in order to maintain the standard of purity. When lights are used, for example, and the products of combustion are allowed to pass into a room, a large supply is required to keep the contained air sufficiently diluted. Thus it is found that 1 cubic foot of coal gas destroys the oxygen of 8 cubic feet of air in combustion, and produces about 2 cubic feet of carbonic acid, besides other impurities. As a common gas-burner burns about 3 cubic feet of gas per hour, the importance of having these deleterious products of combustion carried off by special channels will be readily admitted.

It is evident also that the sick require a larger supply of fresh air than the healthy, for it has been found that when as much as 3500 to 3700 cubic feet have been delivered per patient per hour, hospital wards have not been free from offensive smell. Indeed, no greater proof can be afforded of the value of pure air than the excellent results obtained in surgical cases in times of war, and in medical cases when epidemics are raging, by exposing patients as much as possible to the external air.

SECTION II.—CUBIC SPACE.

This should be large enough to permit the passage of 3000 cubic feet of air per head per hour, without producing perceptible draughts. If the cubic space per head is small, the renewal of air will necessarily be much more frequent than when it is large. Thus, with a space of 100 cubic feet, the contained air must be renewed thirty times per hour, in order that the standard amount be supplied; whereas, with one of 1000 cubic feet, only three renewals of air would be required. What, then, is the minimum amount of cubic space through which the standard amount of fresh air can be passed without perceptible movement? Professor Pettenkofer has answered this

stion experimentally, and has found that by means of
icial ventilation, and with the aid of the best mechani-
contrivances, the air in a chamber of 424 cubic feet
be renewed six times per hour without creating any
eciable air-currents. No doubt, therefore, such a space
is, or one somewhat smaller, can be efficiently ven-
d, provided that perfect artificial means be employed,
the air warmed, but with natural ventilation this
nes impossible. Indeed, a change of air three or four
s per hour is all that can be borne in this country
out discomfort, and this would require an initial air-
of 750 to 1000 cubic feet. Practically speaking,
lifficulties of ventilating small spaces efficiently are
not so much to the movement of the contained air as
e relative position of the inlets, these being of neces-
so near the person that the draughts which are pro-
d become disagreeable or injurious. This is well
plified in the case of prisons. In hard-labour prisons,
e convicts are confined in their cells only during the
s of rest, the cell-space seldom exceeds 200 cubic
The consequence is that in cold or inclement
her these draughts become so unpleasant that many
e prisoners block up the inlets as effectually as they
and of course obstruct the ventilation to a serious
nt. So far as my experience goes, it is difficult, even
the aid of a well-devised plan of ventilation, to sup-
the necessary amount of fresh air per head per hour
out creating perceptible draughts occasionally, if the
e be less than 600 cubic feet. I have further satis-
myself that with the same artificial appliances and
ngements, the air contained in small occupied spaces
mes much more impure than in large spaces. For
nple, in the experiments already alluded to in the last
ter, the cell-space in one-half the prison was 210
c feet, in the other half it was 614. The same means

for extracting the foul air through flues leading from every cell to a foul-air extraction shaft, in which a furnace was kept burning to produce a constant draught, were common to both parts of the building. Moreover, the fresh-air inlets were more amply provided for in the small than in the large cells, and yet the average amount of carbonic acid, after a series of observations, was found to be 1·044 per 1000 volumes in the former, and only ·720 in the latter.

With a small cubic space it is impossible to obtain uniform diffusion of the contained air, if a large amount of fresh air is supplied, because between inlet and outlet a direct current is established, and a considerable quantity of air passes right through without being utilised. Again, it is evident that if the ventilation is impeded or becomes arrested, impurities will collect with far greater rapidity in a small than in a large space, and this of itself is a great argument in favour of the adoption of an ample cubic space as a basis. Dr. de Chaumont, in his remarks on this point, writes:—“Let us suppose two occupied spaces, one of 500 and the other 1000 feet, ventilated so that the ratio of carbonic acid is ·06 per cent, and that from some cause or other the ventilation is arrested in both, the condition will then be as follows:—

“1000 feet “Ratio of impurity.		“500 feet “Ratio of impurity.	
“After one hour .	·12 per cent.	“After one hour .	·18 per cent.
,, two hours .	·18 ,,	,, two hours .	·30 ,,
,, three ,, .	·24 ,,	,, three ,, .	·42 ,,
,, four ,, .	·30 ,,	,, four ,, .	·54 ,,
,, six ,, .	·42 ,,	,, six ,, .	·78 ,,
,, seven ,, .	·48 ,,	,, seven ,, .	·90 ,,

With ordinary means of ventilation (artificial excluded) both Dr. Parkes and Dr. de Chaumont have contended that the cubic space for a healthy adult ought at least to be 1000 feet. It is true this is very much in excess of what is generally obtained. In the crowded dwellings of the poorer classes it seldom exceeds 200 to 250 cubic feet; but then the disastrous effects declare themselves but too clearly in the increased rate of mortality. In metropolitan lodging-houses the allowance per head is as low as 240 cubic feet; and in the Dublin registered lodging-houses it is 300. The Barrack Commissioners, on the other hand, recommended a minimum space of 600 cubic feet for soldiers, insisting at the same time that the air should be renewed at least twice every hour. "The only safe principle," they said, "in dealing with the subject is to have a large margin for contingencies; and the question really is, not whether 600 cubic feet per man be too much, but whether 600 cubic feet per man be enough for all the purposes of warming, ventilation, and comfort." Experiments that have since been made, and particularly those conducted by Dr. de Chaumont, prove most incontestibly that even this comparatively large allowance is inadequate for these purposes; but it was as much as could be obtained at the time, without putting the country to enormous expense. The Commissioners themselves observe:—"It has been said that the question of cubic space is simply a question of ventilation, but it is rather a question as to the possibility of ventilation. The more beds or encumbrances you have in a room, with a limited cubic space, the more obstruction you have to ventilation; the fewer the beds the more easy is it to ventilate the rooms. There are fewer nooks and corners. fewer surfaces opposed to the movement of the air, and less stagnation. We have been in rooms, both in barracks and hospitals, in which the atmosphere was positively offensive with the doors and windows open."

For further remarks on cubic space in hospitals, see Chapter on Hospitals.

In summing up this part of the subject, the following may be accepted as the standard conditions necessary for the requirements of *perfect* health:—

1. That the limit of maximum impurity of air vitiated by respiration ought not to exceed ·6 carbonic acid per 1000 volumes.

2. That to ensure the maintenance of this standard under ordinary circumstances, 3000 cubic feet of pure air must be supplied per head per hour.

3. That for this purpose, and with ordinary means of ventilation, a space of at least 1000 cubic feet should be allowed per head in buildings permanently occupied.

It may be objected that these conditions aim at too high a standard, and that in general they are seldom met with; but it must be remembered, as Dr. de Chaumont has so well pointed out, that they are based on a firm foundation of facts, and that, though it may not be possible to prove in all cases that bad effects result from a neglect of them, it does not follow that such bad effects may not have been produced. In a country like this, with a climate so variable, the cubic space allowance is a most important element in any scheme of ventilation. It should be ample enough to permit of a sufficient supply of fresh air without creating injurious draughts, and yet not too large to interfere with the maintenance of a sufficient and equable temperature during cold weather Where artificial ventilation is provided, and when the fresh air can be heated before entering, it may be as low as 400 cubic feet, but even then the ventilating arrangements must be much more perfect than they usually are In the case of healthy adults, such as soldiers and prisoners, the standard allowance may also be considerably lessened, if care be taken that the free entrance o fresh air at all hours and in sufficient quantity shall no be interfered with. Unfortunately the question of cubi space is a question of large outlay, and hence the desire to economise tends to curtail the minimum not within safe limits, but within limits that will not be attended with glaring injurious effects.

In advocating these conditions, however, it is but right to state that the numerous experiments and weighty opinions of Dr. Angus Smith are somewhat at variance with them. In the first place, Dr. Smith's experiments only give ·4 cubic feet of carbonic acid per hour, which would reduce the requisite amount of fresh air supply per hour to 2000 cubic feet; and, in the second place, Dr. Smith maintains that uniform diffusion of the contained air is the exception and not the rule, and in fact that it does not occur at all. With regard to the first of these points, the discrepancy between Dr. Smith's results and those of other physiologists may be reconciled on the ground that his trials were admittedly not made on large men; but with regard to the second, there still exists considerable divergence of opinion. If by uniform diffusion throughout an occupied space is meant the *exact* uniformity of the chemical composition of the air in every part, then it must be conceded that Dr. Smith is strictly correct; for so long as fresh air is entering and foul air issuing from a room, there will not only be a difference between the composition of the air in the immediate proximity of the inlets and outlets, but there will also be a difference in various parts caused by the currents, however imperceptible these may be. In small occupied spaces, such as prison cells, provided with adequate means for artificial ventilation, the amount of fresh air required to keep the carbonic acid from exceeding ·6 per 1000 volumes must obviously be much less than the amount required per head in a large room, because uniform diffusion is impossible, there being a constant movement of the air from inlet towards outlet. But in a large space the case is different, even though the cubi space per head be not greater than that of the prison cell The entering currents and the currents produced by inequalities of temperature are, in this instance, much more numerous, and produce a much greater mixing of the air, while the impurities given off by respiration have greater scope to be affected by the laws of gaseous diffusion. For all practical purposes, therefore, the condition of uniform diffusion, as applying to a room occupied by several persons, may be accepted as sufficiently accurate; and this being so, the standard amount of fresh air to be delivered per head per hour should, as already stated, be 3000 cubic feet. Indeed, the whole of the controversy between Dr. Angus Smith, on the one hand, and Drs Parkes and de Chaumont on the other, regarding this point, seems to be based on a misunderstanding; each party estimated the requirements of ventilation for a single individual, but under different conditions—the former taking it for granted that the space is occupied by one, the latter that it is occupied by several.

SECTION III.—NATURAL VENTILATION.

Natural ventilation is carried on by the agency of natural forces, such as gaseous diffusion and movements of air produced by inequalities of temperature.

1. *Diffusion.*—The force of gaseous diffusion, upon which the uniform constitution of the atmosphere itsel depends, is manifestly inadequate as a ventilating powe It operates chiefly in producing, as has been already stated a tolerably equal distribution of the gaseous products o respiration and combustion throughout the air contained i a room, but aids only to a very slight extent the remova of these impurities from the room, while it is altogethe inoperative as regards the removal of organic impurities.

2. *Movements of Air produced by Inequalities of Temperature.*—As common air is subject, like other gases, to the laws of gaseous expansion, it undergoes a certain increase or diminution in bulk, according as it is heated or cooled. Warm air is, therefore, lighter than cold air, and hence a constant interchange goes on through every available opening, whenever there is any difference between the outside and inside temperature. The contained air, on being heated, expands, a portion of it escapes, and the colder outside air rushes in to establish the equilibrium. In this way a constant stream of fresh air may be made to enter a room by simply keeping the inside temperature higher than the outside. But in addition to the slighter currents, the movements of the external air, or winds, greatly assist ventilation by their perflating or aspirating action. Perflation is best exemplified in the cross-ventilation which takes place through opposite windows when opened. This is by far the readiest means which can be adopted for removing speedily and effectually aerial impurities from a room, but it cannot always be depended on, on account of the uncertainty of the rate of movement; for if the air be stagnant, there can be little or no perflation, while, on the other hand, if the rapidity of movement is great, perflation becomes insupportable in consequence of the draughts produced. A current of cold air moving at the rate of five or six feet per second becomes unbearable. In spite of this objection, however, cross-ventilation should always be provided for whenever it is practicable, and especially in large rooms, such as hospital wards.

The aspirating action of the wind produces up-currents through chimneys and air-shafts, by creating a partial vacuum in them, which is constantly being filled by the column of air from beneath. The mechanical arrangements which have been proposed or adopted to facilitate the action of these natural ventilating powers are so numerous and varied, that only a brief mention of the more important of them can be given. To utilise the perflating force of the wind, opposite windows should be made to open from the top and bottom, and to obviate the unpleasantness arising from draughts, some such arrangements as the following have been recommended:—

(1.) By having the window so constructed that the top slopes inward when it is opened, so that the entering current of air impinges against the ceiling. If the window is large, as in churches or schools, only a section of the upper part may be made to open in this way.

(2.) By substituting a glass louvre for the top centre pane.

(3.) By having some of the panes doubled; the outer with an open space at the lower edges; the inner with an open space of the same size at their upper edges. The air on entering is thus made to pass upwards between the panes.

(4.) By having some of the panes made of perforated glass, as in Pott's plan.

(5.) By raising the lower sash of the window two or three inches and filling in the opening under the bottom rail with a piece of wood as proposed by Mr. P. H. Bird. This leaves a corresponding space between the meeting rails in the middle of the window through which the entering current of fresh air is directed towards the ceiling.

(6.) By having a part of a pane to open or shut at will by a spring arrangement, as in Boyle's ventilator.

(7.) By fixing a fine wire screen to the top of the window, which unfolds when the window is pulled down, and folds up when the window is shut. As the fine meshes of the screen are apt to become clogged up with dust, this plan is objectionable, except when the windows are of low elevation, as in attic rooms.

Other outlets and inlets may be provided by inserting erforated bricks in the walls near the ceiling. One of the est inlets is the Sheringham valve, which closes at will y a balanced weight. It slopes inwards and upwards hen open, so that the entering current of air, which first asses through a perforated brick or grating, is directed wards the ceiling.

Currall's patent ventilators, supplied by Tonks and ons, Birmingham, are easily applied, and appear to work ery well. The inlet is made suitable for doors, windows, nd walls, and is so arranged as to obviate disagreeable raughts, while the outlet may be inserted in the chimney-reast or an outer wall.

In some cases cross-ventilation can be tolerably well aintained, independently of opposite windows, by means f transverse ventilating boxes or tubes, situated at regular istances, and in close proximity to the ceiling. These oxes or tubes extend from wall to wall, and communicate ith the external air at either end by air-bricks. The des are made of perforated zinc, and there is a diaphragm n the centre of each, to prevent the wind from blowing ght through. According to the direction of the wind, ne-half the tube becomes an inlet for fresh air, which lls gently into the room through the perforated zinc, hile the other half becomes an outlet for the vitiated ir.

This plan does very well for large hospital wards aving an internal corridor running along one side. nner rooms can also be supplied with a certain amount f cross-ventilation in the same way.

Another plan, which has been very much lauded ithin the past year, is that which is associated with the ame of Mr. Tobin of Leeds. It consists in introducing resh air by means of vertical tubes carried for a certain istance up the walls of the room, so as to obviate any discomfort arising from down-draught. In rooms or classrooms with windows only on one side, this is a very convenient method of improving the ventilation. Another method of ventilating by pipes, introduced by Messrs. Shillito and Shorland of Manchester, has also been found to work very well.

The aspirating power of the wind is best utilised by placing cowls on the tops of air-flues or chimneys. They should be made to rotate according to the direction of the wind by means of vanes, and should be so constructed as to prevent the entrance of rain. Among cowls which have received favourable notice may be mentioned the various cowls patented by Banner, Bond, Boyle, Buchan, Ellison, Scott, Dunn and Co., and Wawn and Wilcox.

Louvres are sometimes used instead of cowls, but, unless specially constructed, they are apt to let in the rain and permit down-draughts.

In several plans of natural ventilation the perflating and aspirating powers of the wind are both taken advantage of. Thus, in Mr. Sylvester's plan, which was in use fifty years ago, a large cowl surmounted the fresh air entrance shaft, and by means of a vane was always made to face the wind. The shaft itself was erected at a convenient distance from the building to be ventilated, and of a height varying according to circumstances. In this way the air, so to speak, was blown into the cowl and down the entrance-shaft into a chamber beneath the basement floor, where it could be heated if necessary. It then ascended by tubes leading to the different parts of the building, and finally passed out through a shaft or shafts projecting above the roof, and also fitted with cowls turning away from the wind, so as to act as aspirators.

By a suitable arrangement of shafts and cowls, this mode of natural ventilation can be made to do excellent service in ships, and in buildings so constructed or situted that other ventilating means will not suffice. It vas on this principle that Dr. Arnott ventilated the Field ane Ragged School so successfully. The entrance and xit tubes were both fitted with cowls, the one set turning way from the wind, the other facing the wind. The atter also were of a higher elevation than the former, in rder to increase their extractive power.

A system of natural ventilation, well suited for large ooms, and which has been highly spoken of by Mr. Robon, architect to the London School Board, is that devised y Mr. Potts. It consists of a hollow metal cornice unning continuously round the room, and divided longiudinally throughout its whole length into two separate hannels, by a plate attached to the lower one. The fresh ir is admitted through openings in the wall into the wer channel, and falls imperceptibly into the room rough numerous perforations. The upper channel mmunicates either with the smoke-flue or other air-aft, and receives the vitiated air through a series of nall openings similar to those of the lower channel. As e fresh air, being colder, descends by its own gravity, d the vitiated air, being warmer, rises to the highest oint, there is no doubt that the principles of the system e correct. Mr. Robson strongly recommends it for cility of application to buildings originally erected ithout proper provision for ventilation, for sightliness, onomy of first cost, and self-acting properties.

Another plan, which has been found to work well in chools, has been propossd by Mr. H. Varley. A perrated zinc tube, communicating with the external air, asses along the cornice of three sides of the room, while n the fourth side another perforated tube is connected ith the chimney, which acts as the extraction-shaft.

The plan proposed by Mr. M‘Kinnell, though it beongs to the same category, is less widely applicable than either of these two, because it is only suited for one-storeyed buildings or upper rooms. It consists of two hollow cylinders, one within the other, and of such relative calibre that the transverse area between the tubes is equal to the sectional area of the inner tube. The inner tube is of slightly higher elevation than the outer, and acts as the outlet. The fresh air enters between the tubes, and is thrown up towards the ceiling by means of a horizontal flange surrounding the lower margin of the inner tube. Both tubes should be situated in the centre of the ceiling or roof.

For ventilating workshops or factories, a plan has been advocated by Dr. Stallard, which appears to possess some special merits beyond those of mere novelty. He proposes that the ceiling of every workshop should be formed of zinc or oiled paper pierced by numerous small holes. Above this perforated ceiling, and between it and the roof, or between it and the next floor above, there should be a free space or air-chamber open to the atmosphere on all sides. This plan, while it would not interfere with ventilation by open windows nor with ordinary methods of warming, would give free play to the different modes of natural ventilation, and is intended to supply, as nearly as possible, the conditions of living in the open air, summer and winter, without exposure to extremes of weather.

SECTION IV.

ARTIFICIAL VENTILATION AND WARMING.

It will be convenient to consider these two subjects conjointly.

Artificial ventilation is carried on either by forcing the air into and through a room (propulsion), or by drawing the air out of a room (extraction). These two methods are also spoken of as the *plenum* and *vacuum* systems of ventilation.

Although it may appear to be an easy matter to ventilate a room without any regard to temperature, or to warm it without providing for a due supply of fresh air, it becomes a problem of very considerable difficulty to ensure in all cases that both the ventilation and warming shall be efficient and satisfactory. This difficulty depends in a great measure on the fact that the means employed in ventilating necessarily dissipate and carry off a certain quantity of the heat which should be utilised for warming purposes.

In this country artificial ventilation and warming are usually provided for by open fire-places. The heat is obtained by radiation from the incandescent fire, and by radiation and reflection from the different parts of the grate, while ventilation is carried on by the constant current of heated air rushing up the chimney. Even when there is no fire, the chimney acts as a very efficient ventilating shaft.

When doors and windows are closed and a fire kept burning, the fresh air enters the room through every chink and opening, provided there are no special inlets. Hence it follows that the more closely doors and windows are made to fit, so much greater are the obstacles to the entrance of fresh air. When this is the case, the fire feeds itself by establishing a double current in the chimney, the downward current entering the room in puffs and carrying with it clouds of smoke. Generally, however, doors and windows are not made to fit so closely that a sufficient amount of air for feeding the fire cannot enter, and under ordinary circumstances the supply and circulation are somewhat as follows:—The greater portion of the fresh air enters beneath the door, and is drawn along the floor towards the fire-place. It is warmed to a certain extent during its course by the radiating heat of the fire, and when it approaches the fire-place, part of it rushes up the chimney along with the smoke, while the other part ascends towards the ceiling, and after ascending passes along the ceiling towards the opposite end of the room. During its progress it becomes cooled, and therefore descends to be again drawn towards the fire-place with a fresh supply from beneath the door and through the chinks of the window-frames, if they are not air-tight. As the air which thus enters is usually cold air, it is evident that the room is insufficiently or unequally warmed and badly ventilated. At the end of the room opposite the fire-place the temperature is below the average, and the cold current near the floor chills the feet. Moreover, the air is not properly diffused, so that although a sufficient supply may actually be entering, impurities are apt to accumulate in the centre and upper parts of the room.

The position of the fire-place is likewise a matter of considerable importance. The practice followed by most builders is to place fire-places in external walls, by which means a large amount of heat is wasted. If, on the other hand, they are grouped in the centre of the house, more heat is utilised, and greater equability of the inside temperature is maintained.

With ordinary fire-places it is found that nearly seven-eighths of the heat generated passes up the chimney, along with a quantity of air varying from 6000 to 20,000 cubic feet per hour. While, therefore, a single chimney will on the average act as an efficient ventilating shaft for a room containing from three to six or more persons, it is quite clear that by far the greatest portion of the fuel is wasted as a warming agent. The structure of the fire-place thus becomes a matter of special importance, because not only may the fuel be economised to a considerable extent, but by certain mechanical arrangements an equable temperature may be maintained and the air warmed before it enters the room.

Of the fire-places adapted to meet these requirements, one of the best is the stove devised by Captain Douglas

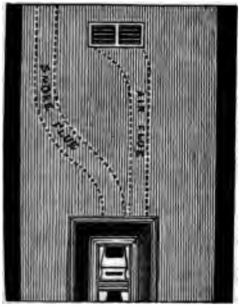

Fig. 1.—Elevation, showing air and smoke flues.

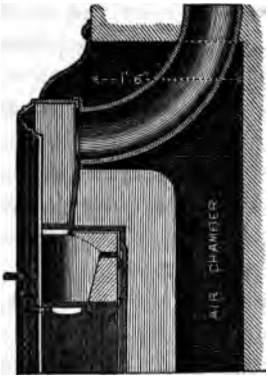

Fig. 2.—Section of grate.

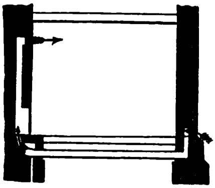

Fig. 3.—Section of a room showing air-duct and flues.

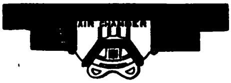

Fig. 4.—Plan of grate and air-chamber.

(After Galton.)

Galton (see Figs. 1, 2, 3, and 4). It provides for an air-chamber at the back, in which the fresh air is heated before it enters the room. If the fire-place be built in an external wall, the inlet for fresh air may be situated immediately behind, but if in an inner wall, a channel communicating with the external air by perforated bricks or gratings, and passing beneath the flooring or behind the skirting, must be laid. On the back of the stove broad iron flanges are cast, so as to present as large a heating surface as possible. These project backwards into the chamber, and this heating surface is further supplemented by the smoke-flue, also of iron, which passes through the chamber, and is made continuous with the chimney. The fresh air heated in this manner enters the room by a louvred opening situated between the fireplace and ceiling, or by two such openings, one at either side of the chimney-breast. The grate itself is so constructed that the greatest amount of obtainable reflected heat is given off, and a more perfect combustion of the smoke effected than with an ordinary grate. The stoves are of different designs and sizes, to suit existing chimney-openings and different sized rooms. They have the same cheerful aspect as the ordinary grate, and produce the same degree of warmth in a room, with a third of the quantity of fuel; besides, the temperature of the room is much more equable, and unpleasant draughts of cold air are avoided. In Boyle's ventilating grates, which are perhaps more ornamental, the heated air enters the room through a transverse fenestrated opening extending along the top of the grate. In Shorland's patent Manchester grate, which has been highly spoken of, the warmed outside air is made to enter the room through the shelf of the chimney-piece. Kitchen stoves have also been constructed on the same principle, and stoves suited for the centre of halls or wards. The smoke-flue of the latter is made to pass out under the flooring, and inside the fresh-air entrance channel, thus supplying a larger heating area for the entering air. The terra-cotta stoves in Herbert Hospital are of this description.

A very cheap and improved fresh-air cottage grate has been devised by Mr. Penfold of London. It is composed of well-burnt fireclay, with a chamber at the back, as in Galton's stove, in which the fresh air can be heated and discharged into adjoining rooms. This plan of supplying adjoining rooms with heated air was first introduced by Cardinal Polignac in 1713.

The people's stove, patented by Mrs. Lewis of the Strand, has also been highly spoken of. It is cheap, economical as regards fuel, free from smoke or smell, and excellently adapted for cooking purposes. Gas is now largely used for cooking purposes, and there are many ranges and small stoves heated by gas which work admirably.

Of the numerous stoves intended to economise fuel, it will be sufficient to notice only a few of those which have been found to work more or less successfully as ventilating stoves.

1. *The Goldsworthy-Gurney Stove.*—This consists of a plain iron cylinder, surrounded by a series of upright gills or flanges, and placed in a water pan, in order that the heat rendered latent by evaporation may be carried to the distant parts of the room in the moistened currents of air which proceed in all directions from the stove. The fresh air enters through a channel opening beneath the stove, and is heated by the warm flanges surrounding it. As the water in the pan is steadily evaporated by the heat of the stove, the air in the room never becomes burnt or over-dried.

2. *Musgrave's Slow Combustion Stove.*—This resembles the Gurney Stove in being surrounded by rows of flanges or ribs, but is more complicated in its internal arrangements. The receptacle for the fuel is lined with fireclay blocks, and is large enough to contain the fuel necessary for twenty-four hours' consumption. As the fire is lighted from beneath, and the stove is charged through a sliding-door at the top, the fire may be kept burning for a whole year without requiring relighting, provided it be regularly fed and the ashes not allowed to accumulate.

Before escaping through the smoke-flue, the smoke an other products of combustion are forced through tw auxiliary spaces in the stove, and impart almost th whole of their heat to the stove with its appendage during their passage. The fresh air to be heated i supplied by a special channel.

3. *Pierce's Pyro-pneumatic Stove-Grate.*—In this stov the fuel is burned in an open grate, surrounded by fire lumps, which impart their heat to the fresh air enterin beneath.

4. *The Calorigen Stove,* lately invented by Mr. George, is adapted for burning gas, or as an open fire-place. The body of the stove is made of thin rolled iron, and contains a coil of wrought-iron tubing, which is open at the top of the stove, and communicates with the external air beneath. The fresh air is warmed during its passage through the coil, and enters the room at a moderate temperature Connected with the gas stove is a cylinder placed outsid the wall, and furnished with two pipes which communicat with the interior of the stove. This cylinder is open a the top, and admits the air necessary for the combustio of the gas, which is warmed to a certain extent by th products of combustion passing along the upper horizonta tube and issuing through the same opening. Waste o heat is thus prevented, and any communication betwee the furnace of the stove and the air of the room i avoided. In the other stove the air of the room supplie the fire. According to Mr. Eassie, C.E., 14 lbs. of coa burned in this stove will suffice to heat a room of 15 fee square for 16 hours. There is no doubt, therefore, tha the Calorigen is economical, and as it affords equabl warmth with good ventilation, it has been highly commended.

The great objection to many of the commoner kind of stoves depends on the fact that their over-heated sur faces dry the air to a very unwholesome extent, even when the fresh air is conveyed by a special entrance channel. Numbers of them, however, are put up without providing any such channel, so that the air not only becomes dry and burnt, but exceedingly close and unpleasant. Evaporating dishes placed on the stoves will assist in remedying this evil, or painting the iron surface with a solution of silica, as suggested by Dr. Bond; but it is much preferable, and in the long-run more economical, to have a good ventilating stove erected in the first instance.

For all ventilating stoves it is necessary that the fresh-air channels should be removed from all sources of contamination, such as drains, closets, stables, etc.; and it is advisable to protect the external openings by perforated bricks or gratings. The size of the stove, and the sectional area of the air-channel, must of course be regulated by the size of the space which is to be warmed and ventilated.

Stove smoke-flues may be either ascending or descending, but in the latter case a pilot-stove or rarefier ought to be fixed at the base of the upright chimney which receives the flue, otherwise the draught may prove faulty. Soot doors should be provided at all the bends, wherever practicable.

With the ordinary grate, the ventilation of a room may be very greatly improved by providing an entrance into the chimney near the ceiling, and to prevent reflux of smoke, the opening should be valved, as in Dr. Arnott's chimney ventilator, or Crossley's noiseless ventilators. One or more openings for the entrance of fresh air could be obtained by inserting perforated bricks or Sheringham valves in the outer walls, also near the ceiling, but at a distance from the fire-place, or by adopting one or other of the several contrivances mentioned in the previous section. Indeed the mistake which is common to the great majority of houses, consists in providing an outlet, generally the chimney, and neglecting to provide an inlet, whereas the essential principle of ventilating demands that there shall be at least two openings, one of which shall act as an inlet, and the other as an outlet, according to circumstances.

Instead of an opening leading directly into the chimney for an outlet, a much better plan is to have a flue running alongside the chimney, the entrance to the flue being situated near the ceiling. The hot air in the chimney warms the flue, and there is thus a constant upward current established without any risk of reflux of smoke. But this is an arrangement which can only be attended to in the original plan of a building; it cannot be applied as an improvement afterwards.

Some architects recommend that all the rooms in a well-constructed house should be supplied with warm air from the hall and staircase. In Mr. Ritchie's plan the air is heated to about 70° Fahr., and enters the various rooms through longitudinal openings over each door. After being diffused through the rooms, it then passes up the chimneys and through flues reaching from the ceiling to the wall-heads under the roof.

Somewhat similar to this is the plan devised some time ago by Drs. Drysdale and Hayward of Liverpool. The fresh air, warmed by a coil of hot-water pipes in the basement, is admitted into a central hall containing the staircase and separate landings, from which it enters the several rooms by suitable openings supplied by valves, and from these again it is conveyed to special outlets in the ceilings, converging to a foul-air chamber under the roof. From this foul-air chamber there is a downcast shaft communicating with the kitchen fire, which is thus made to act as an extraction furnace.

With regard to these and other complicated methods of house-ventilation, it has to be pointed out that no system is to be commended which dispenses with the opening of windows occasionally in order to secure thorough perflation. No doubt, it adds greatly to the comfort of a house if the air in the hall is warmed, and it will also add greatly to comfort if the air thus warmed can be introduced into the rooms by suitable openings; but even in winter the windows should be thrown open for a brief period at least every morning, and in summer, window-ventilation should be chiefly depended on, and the entrance-hall, if louvred in the roof, would act as an extraction-shaft.

Large and compact buildings, such as hospitals, asylums, and prisons, can be very efficiently warmed and ventilated by a suitable arrangement of steam-coils or hot-water pipes. The fresh air, as it enters through openings properly distributed throughout the building, is warmed by passing over the pipes, while the vitiated air may be extracted by means of other coils of heated pipes situated in extraction-shafts.

Another mode of ventilation by extraction, and one which is frequently used in prisons, consists in having a large foul-air extraction shaft or shafts, heated by a furnace at the bottom, and into which foul-air flues, leading from all parts of the building, are conducted. The workmanship in this case requires to be very perfect, so as to prevent any large currents of air reaching the shaft except through the flues.

By a combination of these two methods—viz. heating the fresh air before entering by hot-water pipes, and securing the removal of the vitiated air by flues leading to furnace-shafts—the largest buildings can be well warmed and ventilated. If necessary, the hot-water pipes may be made to pass through shallow basins of water, to ensure a sufficiency of moisture in the contained air.

Almost all large mines are ventilated on this principle of extraction. By means of a furnace at the bottom of the upshaft, the air is drawn down another shaft and made to traverse the various galleries by an arrangement of partitions and double doors. In well ventilated mines as much as 2000 cubic feet of air per head per hour can be supplied in this way, and in fire-damp mines, 6000.

In men-of-war and steam-vessels an iron casing surrounding the bottom of the funnel and upper part of the boilers is utilised as an extraction shaft. When the fires are kept burning, so great is the current which rushes up this shaft, that the air can be drawn through the hatchways from all parts of the vessel, and even the hold and timbers ventilated.

In theatres, and other buildings of a similar description, the chandeliers should always be employed to extract the vitiated air. According to the experiments of General Morin, one cubic foot of gas can be utilised so as to cause the discharge of 1000 cubic feet of air. Apart, therefore, from the great advantages arising from the direct removal of the products of combustion, the aid to ventilation furnished by the extractive power of gas-lights merits special attention, for as a common gas-burner will burn nearly 3 feet of gas per hour, its extractive power could thus be utilised to remove nearly 3000 cubic feet of vitiated air during the same period. Where a large flood of light is required, the "sun-burner" acts very efficiently in this way, and for smaller rooms or workshops, the "box-top sun-burner" is found to answer very well. Rickett's new "ventilating globe-light" ought also to be mentioned amongst the latest improvements in this direction. It is so arranged that so soon as the gas is lighted, an upward current is produced in the main tube, and as this becomes heated, the air in the surrounding tube near the ceiling becomes rarefied and set in motion. In this way the heated air in both tubes is carried to a special shaft or to the chimney, thereby securing the removal of the products of combustion, and a steady current outwards of the vitiated air in the room. Tubes of tin or zinc placed over common burners, and communicating with the external air, or leading into the chimney, would answer the same purpose, where ornamentation can be dispensed with. Indeed, the principles of ventilation by gas-lights are in general so easy of application, and the advantages to be gained are so manifest as regards health, that it is surprising they should still be so greatly neglected.

Extraction by means of a steam jet, and extraction by a fan or screw, are now generally abandoned on the large scale. What is known as the Archimedean-screw ventilator, however, has been lately recommended for small air-shafts, and has also been applied to large factories, where it may be worked by hand or steam power. In mines, the fan has been made to extract as much as 45,000 cubic feet of air per minute.

The system of ventilation by propulsion was first introduced by Dr. Desaguliers in 1734. It is carried on by means of a fan enclosed in a box, which can be worked by hand, horse, water, or steam power. The air enters through an opening in the centre of the box, and is thrown by the revolving fan into a conduit which communicates by proper channels with the different parts of the building. In France and America the fan is employed in the ventilation of several of the large hospitals, the air being forced into a basement chamber, where it is heated before it enters the wards. This is known as Van Hecke's system. In this country St. George's Hall, Liverpool, may be cited as affording an example of ventilation by propulsion on the large scale. The air is taken from the basement, and washed by being passed through a thin film of water thrown up by a fountain. It is then passed in cold weather into vessels for the purpose of being warmed, and in which it can be moistened by a steam jet whenever the difference between the dry and wet bulb exceeds 5°, and finally, it is propelled along different channels into the hall. In summer, the air in the conduits is cooled by the evaporation of water.

Various other methods of propulsion have been tried, such as the bellows' arrangement proposed by Dr. Hales, or the gasometer pump worked by hydraulic pressure planned by Dr. Arnott, but mostly all of them have fallen into disuse.

Concerning the relative merits of these two systems of ventilation, viz. extraction and propulsion, the balance of evidence is most decidedly in favour of the former, as regards cost, efficiency, and stability. In either system, natural ventilation plays a most important part, whether it be taken into consideration in the construction of buildings or not; and hence every facility should be afforded for its operation, without at the same time permitting its disadvantages to take effect. For dwelling-houses, workhouses, asylums, barracks, and hospitals, there is no doubt that natural ventilation, aided by the extractive power of the heat generated in warming and lighting, is by far the best system. On the other hand, buildings such as prisons, theatres, etc., must be ventilated by mechanical appliances, and experience has proved that these should provide for ventilation by extraction.

General Considerations.—With regard to the relative position of inlets and outlets, there seems to be some difference of opinion. Theoretically, the inlets for the fresh air should be situated near the floor, and the outlets near the ceiling: but the question of temperature interferes with the practical application of this rule. If the air is not warmed before entering, the inlets should be at least 9 or 10 feet from the floor, or close to the ceiling, and so constructed that the cold air will impinge against the roof, and fall gently into the room. They should slope upwards to prevent entrance of rain, and should communicate with the external air by means of perforated bricks or gratings so as to divide the entering current and break its force. With vertical tubes such as Tobin's or Shillito's tubes, the inlets need only reach about six feet from the floor. Sliding covers, valves, or rotatory discs might also be provided, in order that they may be partially or totally closed during rough weather. If the air is warmed before entering, the inlets may be situated, and generally are situated, near the level of the floor. But in either case it is essential that they should be equally distributed throughout the room, to ensure proper diffusion, and that the structural arrangements should permit of their being readily cleaned out, because dirt is sure to accumulate.

The outlets, as already stated, are best situated in or near the ceiling, not only because air vitiated by respiration tends to ascend on account of its lessened density, but because experiment proves that, given the same extractive power and the same size of outlet, a greater volume of air passes up a flue whose orifice is near the ceiling than up one whose orifice is near the floor. Inlets and outlets should not be situated near each other, otherwise the entering air will be extracted without being first diffused throughout the room.

Outlet tubes, or foul-air flues, as they are generally called, should be smooth, so as not to impede the current of air by friction, and in systems of ventilation by extraction, they should be air-tight. When built in external walls and only plastered, I have frequently satisfied myself by experiment that the outside air finds its way into the flue and sometimes in such volume that though there may be a good current issuing from the top, scarcely any current can be detected entering it at the bottom. I have also found that when the wind beats strongly against the side of a building, with foul-air flues situated in the outer walls, a current of air may actually be issuing from both orifices at the same time. The experiments of Pettenkofer explain how readily such an occurrence may take place, for he has proved beyond doubt that even under ordinary atmospheric conditions, a very considerable interchange of gases takes place through common dry-plastered walls, and indeed, as the sick often experience, very perceptible draughts find their way through outer walls when a stiff breeze is blowing. All foul-air flues, therefore, should be as nearly air-tight as possible, and if they were made of metal tubing, or of glazed earthenware, they would not only satisfy this condition, but would serve greatly to lessen the friction, which is such an impediment to ready extraction through common plastered flues. It is further evident that, when it can be avoided, they should not be situated in external walls, because in cold weather the air becomes cooled as it ascends, and unless the extractive power is very considerable, the increased weight of the column of air by loss of heat will counteract the extractive force. Where there is no system of artificial extraction, it thus often happens that outlets become inlets, and inlets outlets.

Another very important point remains to be considered, namely, the sectional area of the inlets and outlets. As atmospheric conditions are constantly varying, it is obviously impossible to fix upon any size which will meet every requirement. The only alternative, therefore, is to provide an area that will suit the majority of cases, and which will be capable of being increased or diminished according to circumstances. Dr. Parkes has pointed out that in this country a size of 24 square inches for inlet *per head*, and the same for outlet, is the one best adapted to meet common conditions. Theoretically, the sectional area of the outlets should vary according to the height of the foul-air flues, and the Barrack Commissioners have accordingly recommended that it should amount to 1 square inch for every 50 cubic feet of space for upper floors, to 1 square inch for every 55 cubic feet for rooms below, and to 1 square inch for every 60 cubic feet for rooms on the ground-floor, in buildings of three storeys. Practically, however, these nice distinctions may be disregarded, because the friction in long flues lessens very considerably the advantage in extractive power attaching to them, on account of their greater height, and also because, in the great majority of cases, the column of air in the flue increases in density the higher the flue. In prisons, where the cubic space per head is comparatively small, the sectional area of inlets and outlets should be at least 20 square inches per head. In barracks, hospitals, etc., the separate inlets should not exceed 1 square foot, otherwise the entering air will be badly distributed.

More precise details with regard to the ventilation of hospitals will be given in the chapter on hospitals.

CHAPTER V.

EXAMINATION OF AIR AND VENTILATION.

A DETAILED examination of the sufficiency of ventilation in any particular case will embrace the following inquiries:—

1. The arrangements as regards cubic space, the relative size and position of inlets and outlets, the distribution of the air, and the amount of fresh air supplied.
2. The examination of the contained air by the senses.
3. Chemical examination of the contained air.
4. Microscopical examination of suspended impurities.
5. Examination as regards temperature, moisture, etc.

SECTION I.—EXAMINATION AS REGARDS VENTILATING ARRANGEMENTS.

The measurement of the cubic space is a simple question of mensuration, but corrections must be made for furniture, bedding, etc., and for inequalities in the contour of the space to be examined. For instance, the displacement caused by solid projections into the room must be deducted, and the cubic contents of open recesses added. The allowance for each bedstead and bedding may be estimated at 10 cubic feet, and for the space occupied by the body of each person at 3 cubic feet.

After the exact cubic space per head has been ascertained, the next points to be inquired into are the relative position and size of inlets and outlets. Perforated bricks *and gratings* can be approximately estimated, as regards their total open sectional area, by taking their actual superficial area, and calculating the relative size of the interstices. Inlets should be inspected as regards their freedom from accumulation of dust, etc., and outlets as regards the presence of any impediments to the ready exit of the vitiated air. Where there are open fire-places, the sectional area of the smoke-flue must also be ascertained. The existence or otherwise of unpleasant draughts, and the relative position of doors and windows, and how far they assist in the ventilation of the room, are other items which must not escape notice. If the system of ventilation is artificial, it should be examined in all its details, and in this examination great assistance will be derived from inspecting the architect's plans, whenever they can be procured.

The directions of air-currents in a room can be ascertained by means of the smoke from smouldering cotton velvet, fibres of floss-silk, small pieces of feather, small balloons filled with hydrogen gas, etc. The flame of a candle is often used for the same purpose, but it is of no value when the currents are delicate, because it is unaffected by them, but is of considerable service in showing whether air is entering or issuing through any opening. Very frequently, as has already been pointed out, openings that are meant to be inlets act as outlets, and *vice versa*, or the movement of air in them may be unstable, intermittent, and reversed in its action, now entering and now issuing through the same opening.

All these points, and others which may arise from peculiarities of structural arrangement, must be carefully inquired into, and the various measurements and observations noted down as they are made. When the ventilation is intended to be carried on independently of open doors and windows, these should be closed during the examination.

In determining the rate of movement through the various openings, an instrument called an anemometer is generally used. This may briefly be described as a miniature windmill. The little sails, driven by the air-current, set in motion a series of small cogged wheels, which move an index or indices on a dial-plate. The velocity of the current can thus be read off for a given time, in the same way as the amount of gas which has been consumed is ascertained from a gas-meter. A very beautiful and delicate instrument of this description has been constructed by Mr. Casella, of Hatton Garden, with indices on the dial-plate indicating the velocity of an air-current in feet, hundreds of feet, thousands, etc., up to millions. By moving a catch, the machinery may be stopped at any moment of time. With this instrument, the rate of movement of air through any opening is readily, and, as a rule, accurately ascertained. Before using it, the index indicating feet in units should be set at zero, and the relative position of as many of the other indices as may be deemed necessary noted down. When the instrument is placed in the air-current, time is called, and the catch moved to set the machinery free. At the end of one minute, two minutes, etc., according to the length of period of observation, time is again called, and the machinery immediately stopped by means of the catch. The linear dimension of the current is then read off, and if this is multiplied by the sectional area of the opening, the volume of air which has passed through in a given time can be easily calculated in cubic feet. When the instrument is placed in a tube or shaft, it should be put well in, but not quite in the centre, because the velocity of the current in the centre is greater than at the sides of the tube. Should the shaft be large, the rate of movement ought to be taken at different parts, and the average ascertained. So also, when the rate of movement is irregular, several observations should be made, and the average of the whole of them will give the approximate velocity of the current. If placed in a tube whose sectional area exceeds but very little the space occupied by the revolving sails, the results cannot be depended on; and when placed at the entrance of a tube, for example, against a perforated air-brick or grating, the velocity of the current indicated by the anemometer is considerably less than what exists in the tube. In these cases the instrument should be exactly fitted into an opening in a box, large enough to cover completely the mouth of the tube, by which means the whole of the air passing through the tube may be made to pass through the opening in the box.

The amount of air found to be issuing up chimneys or other outlets is a far more reliable index of the fresh-air supply than the amount actually ascertained to be entering through the inlets; and indeed the fresh-air supply can only be fairly estimated in this way. As already stated, the air enters through every chink and cranny, and in dry plastered walls may enter, to no slight extent, through the walls themselves. Hence the difference between the amount of air found to be entering through the regular fresh-air inlets, and that found to be issuing through the outlets, is often very great. In a ward containing 15 beds, with one door, eight windows, and four inlets for fresh air, I have found that while only 880 cubic feet of fresh air were entering through the inlets per bed per hour, as much as 3150 were found to be issuing up the two chimneys and the three extraction-flues of the ward. During the experiments the door and windows were shut, and brisk fires kept burning in the two ventilating fire-places. The large amount, therefore, of 2270 cubic feet per bed per hour entered through chinks in the window-frames, and beneath and around the closed door. Very probably, in this instance, a considerable amount was also drawn, by the extractive force of the chimneys and flues, through the walls, inasmuch as they were built of brick, and were only whitewashed and not plastered.

When an examination of the respired air itself is intended, a suitable time must be selected, during which all the conditions of the efficiency of the ventilation, in any given instance, can be fairly put to the test. Take an hospital ward, for example. It is necessary that all the beds should be occupied, that windows and doors be kept shut, if ventilation is intended to be effectually carried on without them, and that an hour should be selected in the night-time when the greatest accumulation of impurities is likely to occur. Any hour between midnight and 5 A.M. would meet this condition in most cases. In order to make the examination as complete in detail as possible, it is necessary to have a wet and dry bulb thermometer placed outside some time previously, and several others fixed at different positions in the ward. The outside and inside temperature can thus be compared, and the relative hygrometricity of the air indoors and outdoors ascertained. If the barometer is read off at the same time, and the state of the weather recorded, all the meteorological data are obtained which are usually considered necessary for a full and exhaustive report.

SECTION II.—THE EXAMINATION OF THE CONTAINED AIR BY THE SENSES.

With a little practice, this method of examination gives tolerably reliable results; but it is necessary that one should remain for some short time in the open air, before entering the ward or room to be examined, otherwise the sense of smell is likely to be blunted and unable to appreciate the degree of closeness or foulness. One of the terms, "not close," "rather close," "close," "very close," "foul," "very foul and offensive," will indicate, with sufficient accuracy, the degree of perceptible impurity in the majority of cases. The following selections from Dr. de Chaumont's experiments show how closely the sensations accord with the different degrees of impurity indicated by the percentage of carbonic acid:—

At ·1408 per cent.	Extremely close and unpleasant.	At ·0843 per cent.	Not very foul.
„ ·1090 „	Extremely close.	„ ·0804 „	Close.
„ ·0962 „	Very close.	„ ·0658 „	Not very close.
„ ·0921 „	Close.	„ ·0568 „	Not close.

SECTION III.—CHEMICAL EXAMINATION.

1. *Carbonic Acid.*—In the chemical examination of respired air, the chief point to be determined is, the amount of carbonic acid per 1000 volumes. Pettenkofer's method is the one most generally adopted, because it is alike accurate and easy of application. For the analysis, which is volumetric, French weights and measures are used. The following apparatus and solutions are also required.

(1.) Two or more glass jars, each capable of holding 4000 to 6000 centimetre cubes, and fitted with india-rubber caps.

(2.) A Mohr's burette, graduated into centimetre cubes and tenths, fitted with pinch-cock, and large enough to hold 50 or 100 centimetre cubes.

(3.) A narrow glass measure, marked to measure 30 and 60 centimetre cubes exactly.

(4.) A pair of bellows or a bellows-pump.

(5.) Turmeric paper specially prepared. (Turmeric powder should be boiled in alcohol, and ordinary filtering paper steeped in it, then washed and dried.)

(6.) Pure clean lime water. (Both Dr. Angus Smith, and lately Pettenkofer, prefer baryta water, but I follow in my description the plan pursued by Drs. Parkes and de Chaumont, according to which my own analyses have been made.)

(7.) A solution of crystallised oxalic acid, 2·25 grammes to the litre of distilled water.

The capacity of the glass jars must be accurately determined by means of a litre measure graduated into centimetre cubes, and it is convenient to affix the cubic contents, expressed in centimetre cubes, to each jar. Before being used it is necessary that the jars should be perfectly clean and dry.

The analysis depends on the relative degree of causticity of the lime water before and after it has absorbed the carbonic acid contained in the sample of air to be examined. Thus 1 cubic centimetre of the above solution of oxalic acid exactly neutralises 1 milligramme (·001 gramme) of lime; and hence the amount of lime contained in a given quantity of lime water can be readily determined by adding the solution until the point of neutralisation is reached. The amount of oxalic acid solution required for neutralisation expresses the causticity of the lime water. If now the causticity of the lime water is known before and after it has absorbed the carbonic acid in the air contained in the glass jar, the difference will give the amount of lime in milligrammes which has united with the carbonic acid, and the amount of the latter is obtained by calculating according to the atomic weights.

The amount of neutralisation is determined by means of the turmeric paper. The test solution of oxalic acid should be run into the measured quantity of lime water from the burette, and the mixture constantly stirred with *a glass* rod. Every now and again a small drop of the mixture is conveyed on the tip of the rod to the turmeric paper, and one can readily judge by the tint of the stain when the point of neutralisation is approached. With pure lime water the stain produced is an intense dark brown, and as the oxalic acid solution is added, it becomes gradually paler on each application, until at last the centre of the stain is not tinted, and the margin alone appears as a delicate brown ring. The solution should now be carefully added drop by drop, and when the tint of the ring also disappears, the point of neutralisation has been reached.

In making a single analysis, it is advisable to use two jars, because otherwise a repetition of the experiment would not be possible were it required. Under ordinary circumstances, however, as many analyses can be made as there are jars used for collecting samples of the air from different parts of the same room or building. The air to be examined is forced into the jars by means of a pair of bellows, and, by a suitable arrangement of tubing connected with the bellows, it can be pumped into them from any part of the room. In the case of small occupied spaces, such as prison-cells, when it is not desirable to disturb the ventilation by opening the door, the contained air can in this way be pumped into the jars through any opening, such as the inspection hole in the door,—care being taken that the tubing and its connection with the bellows are perfectly air-tight, and that the bellows-valve acts efficiently.

Instead of bellows, a bellows-pump may be used, but in either case the nozzle should be long enough to reach the bottom of the jar. Dr. Angus Smith prefers using the bellows-pump, exhausting the air in the jar, and thus ensuring that its place shall be taken by the air to be examined. Pettenkofer and Dr. de Chaumont, on the other hand, pump the air into the jar; but either method answers very well, provided that care be taken that the jar is really filled with the air to be examined.

After the jar has been filled 60 cubic centimetres of lime water are introduced, and the mouth of the jar closed by a tight-fitting india-rubber cap. If tubing has been used to convey the air from a distant part of the room, or from a small inhabited place without entering it, it is necessary that this part of the experiment should be performed rapidly, in order to prevent escape by diffusion, and therefore the measured quantity of lime water should be ready to be poured into the jar whenever the nozzle of the bellows is withdrawn. The jar is then well shaken, so that the lime water is made to wash the contained air thoroughly, and afterwards is left to stand for a period of not less than six or eight hours, and not more than twenty-four. 60 cubic centimetres are introduced, in order that 30 may be taken out for analysis. So much of the lime water adheres to the sides of the jar, that the whole amount introduced cannot be poured out; and hence, if a repetition of the experiment is necessary another jar must be used.

In making the analysis, 30 cubic centimetres of the lime water which has been employed are poured into a mixing jar, and its causticity determined as above described by the test solution. Then 30 cubic centimetres are taken from the jar, and the causticity also determined The causticity of the lime water is found to vary from 34 to 41, according to its strength; in other words, from 34 to 41 cubic centimetres of the oxalic acid solution will be required for neutralisation, while the causticity of the lime water in the jar will be lessened in proportion to the amount of carbonic acid in the contained air. The difference between the first and second operations is doubled to account for the 30 cubic centimetres left in *the jar,* and the product gives the amount of lime which has combined with the carbonic acid. The amount of the latter, as already observed, is obtained by converting weight into measure according to the atomic weights, and in one sum the factor is found to be ·39521. The capacity of the jar being known, and a deduction of 60 cubic centimetres made for the space occupied by the lime water, the amount of carbonic acid becomes a question of simple proportion. Thus, to take an example —Suppose the causticity of 30 cubic centimetres of the lime water is 39·5, and the causticity of the lime water in the jar is 33·5; suppose also that the capacity of the jar is 5060 cubic centimetres; then, to find the ratio of carbonic acid per 1000 volumes, that is per 1000 cubic centimetres, the problem is as follows:—

$(5060 - 60) : 1000 :: [(39{\cdot}5 - 33{\cdot}5) \times 2 \times {\cdot}39521] : X$

therefore $X = \frac{6 \times {\cdot}79042}{5} = {\cdot}948$ carbonic acid per 1000 volumes.

It will thus be seen that the calculations may be simplified by adopting the following rule:—Multiply the difference between the causticity of the lime water, before and after it has been placed in the jar, by 790, and divide this sum by the number of centimetre cubes contained by the jar, *minus* 60. The result will be the ratio of carbonic acid per 1000 volumes.

But a certain correction must be made for temperature, according as it is above or below the standard of 62° Fahr. As the co-efficient of expansion of air is ·0020361 for every degree Fahr., the rule for correction may be stated with sufficient accuracy thus:—For every 5° above 62° add 1 per cent to the amount of carbonic acid calculated as above, and deduct the same percentage for every 5° below 62°.

If the place of observation is much above the sea-level, a correction must also be made for the difference of atmospheric pressure. The standard barometric pressure being 30, the *formula for this* correction is as follows:—

30 : (observed height of barometer) :: capacity of jar : Z. The result expressed by Z is substituted for the actual capacity of the jar in the calculation for carbonic acid.

Amongst various popular tests for the estimation of the carbonic acid in air vitiated by respiration, the following, proposed by Dr. Angus Smith, is worthy of notice, because it does not require skilled manipulation, nor is it hampered with troublesome measurements or calculations. The method is based upon the fact that the amount of carbonic acid in a given quantity of air will not produce a precipitate in a certain given quantity of lime water, unless the carbonic acid is in excess. This will be better understood by comparing the different columns in the subjoined table, which is taken from Dr. Smith's work on *Air and Rain*:—

EASIEST PROPOSED HOUSEHOLD METHOD.

TABLE.—*To be used when the point of observation is "No precipitate."* Half an ounce of lime water containing ·0195 gramme lime.

Air at 0° C. and 760 Millim's bar.

Carbonic acid in the air. Per cent.	Volume of air in cubic centimetres.	Size of bottle in cubic centimetres.	Size of bottle in ounces avoirdupois.
·03	571	584	20·63
·04	428	443	15·60
·05	342	356	12·58
·06	285	299	10·57
·07	245	259	9·13
·08	214	228	8·05
·09	190	204	7·21
·10	171	185	6·54
·11	156	170	6·00
·12	143	157	5·53
·13	132	146	5·15
·14	123	137	4·82
·15	114	128	4·53
·20	86	100	3·52
·25	69	83	2·92
·30	57	71	2·51

Columns 1 and 2 give the ratio of carbonic acid in the quantity of air which will produce no precipitate in half an ounce lime water; column 3 is the same as column 2, with the addition of 14·16 cubic centimetres, or half an ounce, to give the corresponding size of bottle; and column 4 gives the size of bottle in ounces avoirdupois. It will thus be seen that different-sized bottles containing half an ounce of lime water will indicate approximately the ratio of carbonic acid in the air contained in them, by giving no precipitate when the bottle is well shaken. Thus, if a bottle of 10½ oz. is used, and there is no precipitate, it will indicate that the ratio of carbonic acid does not exceed ·06 per cent; or if one of 8 oz. is used, and there is also no precipitate, it will indicate that the ratio does not exceed ·08, and so on. Dr. Smith says that "the lime water may be prepared of the same constant strength so closely that we may neglect the difference. Burnt lime is slaked with water and dissolved by shaking. It is then kept in a bottle to stand till it is clear. The bottle or bottles used should be wide-mouthed, so that they can be readily cleaned and dried, and the air to be examined may be made to enter them by inhaling the air contained in them through a glass or caoutchouc tube, care being taken not to breathe into the bottle."

As a practical application of this method, which can be practised by any one, Dr. Smith proposes the following rule:—"Let us keep our rooms so that the air gives no precipitate when a 10½ oz. bottleful is shaken with half an ounce of clear lime water."

2. *Organic Impurities.*—To obtain an approximate estimate of the organic impurities, the air may be drawn through, or washed, in a very dilute solution of potassium permanganate of known strength. The result is stated in the number of cubic feet of air which it takes to decolorise ·001 gramme of the potassium permanganate in solution.

The method pursued by Dr. Angus Smith is somewhat different from this. He takes about 30 cubic centimetres of pure water, and adds to it a small amount of known solution of the potassium permanganate. This solution is shaken up with the air in the bottle; the air is then drawn out by a bellows-pump, and another bottleful washed, and so on until the whole colour is removed, or a sufficient amount to enable him to test the remainder, so as to be able to estimate the difference. The actual amount of oxygen taken is then calculated, and the results stated in grains per million cubic feet of air.

3. *Ammonia.*—The estimation of the ammonia, organic and albuminoid, is a still more delicate and difficult process. The water used for washing the air must be perfectly pure, and should therefore be boiled with soda or potash before distillation. From 30 to 50 cubic centimetres are then introduced into a bottle of about 2000 cubic centimetres, and the washing of successive bottlefuls of the air to be examined is continued until the water is sufficiently charged with impurities. The testing afterwards is the same as that proposed by Messrs. Wanklyn, Chapman, and Smith, for organic impurities in water, and the results are stated in grains per million cubic feet of air.

For further information concerning these methods of analysis, and for an account of numerous valuable experiments, see Dr. Angus Smith's work already quoted, and Dr. Fox's work on the *Sanitary Examinations of Water, Air, and Food.*

SECTION IV.—MICROSCOPICAL EXAMINATION.

Suspended matters contained in the air may be collected by drawing the air through distilled water by means of an aspirator, by washing the air in distilled water, or by employing an instrument called an aeroscope. When either of the first two processes is employed, the suspended matters are merely allowed to subside, and are then removed to a glass slip for examination. The aeroscope invented by Pouchet consists of a funnel-shaped tube, ending in a fine point, beneath which is placed a slip of glass moistened with glycerine. Both glass and tube are enclosed in an air-tight chamber, which is connected by tubing with an aspirator, so that when the stopcock of the aspirator is turned, and the water allowed to escape, the air is drawn through the tube, and impinges against the slip of glass moistened with glycerine, by which the suspended matters are arrested.

SECTION V.—EXAMINATION AS REGARDS TEMPERATURE AND MOISTURE.

1. *Temperature.*—The various points connected with the temperature of the contained air, such as its equability, sufficiency, etc., are readily ascertained by a judicious distribution of thermometers throughout the space to be examined, and by comparing the outside with the inside temperature. The efficiency of the heating apparatus is of course best tested during very cold weather and in the night time. When open fire-places are used the temperature should be noted at the remote parts of the room, and if the air is heated before entering, it is advisable to take the temperature at the point of delivery, and to ascertain whether it is well diffused or not.

2. *Moisture.*—The amount of watery vapour, or the hygrometricity of the contained air, may be determined by hygrometers such as Daniell's and Regnault's, or by wet and dry bulb thermometers. The latter are the most convenient and reliable, but they should be distributed some two or three hours before the observations are made. The wet bulb is covered with muslin, over which

there is twisted a small skein of cotton, which dips into a little vessel containing either distilled or rain water. The cotton should be boiled in ether, or soaked in a solution of sodium carbonate, to free it from fat, so that the water may readily ascend by the force of capillary attraction.

Unless the air is saturated with moisture, the temperature of the wet bulb is always below the temperature of the dry, and the number of degrees of difference between them varies according to the amount of watery vapour present. This is generally represented in relative terms. For example, the point of complete saturation being assumed to be 100, any degree of dryness may be stated as a percentage of this, and can be conveniently ascertained by reference to the table given on the opposite page, which has been calculated from Mr. Glaisher's large tables. The table is read by taking the temperature of the dry bulb, and the difference between it and that of the wet bulb, and noting the number given at the intersection of the two columns. This number gives the relative humidity.

The relative humidity of the air out of doors should also be ascertained at the same time, by way of comparison.

In carrying out experiments in ventilation, the hair-hygrometer gives sufficiently accurate results, and possesses a considerable advantage over the dry and wet bulb thermometer in rapidity of indication. It consists of a human hair freed from fat by steeping it in ether, or a solution of liquor potassæ, one end of which is fixed, and the other attached to a small needle, and according as the hair becomes shorter or elongates, the needle traverses a graduated scale, and thus indicates the relative humidity. After a time, however, it loses its delicacy, and requires to be re-adjusted.

TABLE *of the Relative Humidity given by the difference between the Dry and Wet Bulb.*

Temperature of the Dry Bulb.	DIFFERENCE BETWEEN THE DRY AND WET BULB.															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	RELATIVE HUMIDITY, SATURATION = 100.															
90	100	95	90	85	81	77	73	69	65	62	59	56	53	50	47	44
89	100	95	90	85	81	77	73	69	65	61	58	55	52	49	46	43
88	100	95	90	85	81	77	73	69	65	61	58	55	52	49	46	43
87	100	95	90	85	81	77	73	69	65	61	58	55	52	49	46	43
86	100	95	90	85	80	76	72	68	64	61	58	55	52	49	46	43
85	100	95	90	85	80	76	72	68	64	61	58	55	52	49	46	43
84	100	95	90	85	80	76	72	68	64	60	57	54	51	48	45	43
83	100	95	90	85	80	76	72	68	64	60	57	54	51	48	45	42
82	100	95	90	85	80	76	72	68	64	60	57	54	51	48	45	42
81	100	95	90	85	80	76	72	68	64	60	56	53	50	47	44	41
80	100	95	90	85	80	75	71	67	63	59	56	53	50	47	44	41
79	100	95	90	85	80	75	71	67	63	59	56	53	50	47	44	41
78	100	94	89	84	79	75	71	67	63	59	56	53	50	47	44	41
77	100	94	89	84	79	75	71	67	63	59	56	53	50	47	44	41
76	100	94	89	84	79	75	71	67	63	59	55	52	49	46	43	40
75	100	94	89	84	79	74	70	66	62	58	55	52	49	46	43	40
74	100	94	89	84	79	74	70	66	62	58	55	52	48	45	43	40
73	100	94	89	84	79	74	70	66	62	58	54	51	48	45	42	40
72	100	94	89	84	79	74	69	65	61	57	54	51	48	45	42	39
71	100	94	88	83	78	73	69	65	61	57	53	50	47	44	41	38
70	100	94	88	83	78	73	69	65	61	57	53	50	47	44	41	38
69	100	94	88	83	78	73	68	64	60	56	53	50	47	44	41	38
68	100	94	88	83	78	73	68	64	60	56	52	49	46	43	40	37
67	100	94	88	83	78	73	68	64	60	56	52	49	46	43	40	37
66	100	94	88	83	78	73	68	64	60	56	52	48	45	42	40	37
65	100	94	88	83	78	73	68	63	59	55	51	48	45	42	39	36
64	100	94	88	82	77	72	67	63	59	55	51	48	45	42	39	36
63	100	94	88	82	77	72	67	63	59	55	51	47	44	41	38	35
62	100	94	88	82	77	72	67	62	58	55	50	47	44	41	38	35
61	100	94	88	82	77	72	67	62	58	54	50	47	44	41	38	35
60	100	94	88	82	76	71	66	62	58	54	50	46	43	40	37	34
59	100	94	88	82	76	71	66	61	57	53	49	46	43	40	37	34
58	100	93	87	81	76	71	66	61	57	53	49	46	43	40	37	34
57	100	93	87	81	75	70	65	61	57	53	49	45	42	39	36	33
56	100	93	87	81	75	70	65	60	56	52	48	44	41	38	35	32
55	100	93	87	81	75	70	65	60	56	52	48	44	41	38	35	32
54	100	93	86	80	74	69	64	59	55	51	47	43	40	37	34	31
53	100	93	86	80	74	69	64	59	55	51	47	43	39	36	33	30
52	100	93	86	80	74	69	64	59	54	50	46	42	39	36	33	30
51	100	93	86	80	74	68	63	58	54	50	46	42	38	35	32	29
50	100	93	86	80	74	68	63	58	53	49	45	41	37	34	31	29
49	100	93	86	79	73	67	62	57	53	49	45	41	37	34	31	28
48	100	93	86	79	73	67	62	57	52	48	44	40	36	33	30	
47	100	93	86	79	73	67	61	56	51	47	43	39	36	33	30	
46	100	93	86	79	73	67	61	56	51	47	43	39	35	32	29	
45	100	92	85	78	72	66	60	55	50	46	42	38	34	31	28	
44	100	92	84	78	71	65	59	54	49	45	41	37	34	31	28	
43	100	92	84	78	71	65	59	54	49	45	41	37	34	31	28	
42	100	92	84	78	71	64	59	54	49	44	40	36	34	30	27	
41	100	92	84	77	70	64	58	53	48	43	39	35	31	28		
40	100	92	84	77	69	63	57	52	47	42	38	34	31			
39	100	92	84	77	69	63	57	51	46	42	38	34				
38	100	91	83	75	68	62	56	50	45	41	37					
37	100	91	83	75	68	61	55	49	44	39						
36	100	91	82	74	66	59	53	47	42							
35	100	90	80	72												
34	100	89	79	72												
33	100	89	78	70												
32	100	87	75													

In a room well ventilated and warmed the humidity ought to range between 73 and 75 per cent, the temperature should not fall below 60° Fahr., and the carbonic acid, as previously stated, should not exceed ·6 per 1000 volumes.

In the examination of the air contained in the crowded dwellings of the poorer classes, the senses will alone sufficiently indicate the degree of impurity, but in all cases the cubic space per head, and the means of ventilation, should be carefully noted, because otherwise any suggestions as regards improvements will at the best be haphazard, and possibly ill-advised. The amount of cubic space obtainable in the houses of the poor, and especially in rural districts, will be more fully discussed in Chapters IX. and XV.

CHAPTER VI.

WATER.

SECTION I.—SOURCES.

ıpplies of fresh water are derived from the con-
on of the aqueous vapour contained in the
here. Whether this falls to the earth in the form
or snow, a certain portion of it runs off the sur-
d gravitates towards the sea; another portion sinks
e soil, and, passing through strata which are more
porous, or through fissures in rocks, again reappears
ngs and wells; a third portion is evaporated where
; and the remainder becomes absorbed in the
al composition of minerals, or is utilised in the
es of growth and decay of animal and vegetable

e rainfall which flows on the surface collects in
3, lakes, and rivers, according to the conformation
ground, while the water flowing under ground oozes
surface either imperceptibly or in springs, and
ally unites with the surface water in its accumula-
lakes, or in its onward progress towards the sea.
ıe immediate sources of water-supply may therefore
ısified as rain water and water from springs, wells,
or lakes.

Rain Water.—Rain Water is highly aerated, and,
uncontaminated by the receiving surface or by air-
ities, is healthy and pleasant. But frequently,

according to the analyses of the Rivers' Pollution Commissioners, it contains a large amount of organic matter, and in this country is usually far less pure than water derived from deep wells and springs. This is not to be wondered at, when we consider that the atmosphere in a thickly populated country like Great Britain becomes the recipient of vast quantities of excremental dust and effluvia, of smoke particles, and the products of animal and vegetable decay. It is, therefore, seldom stored on premises except for washing purposes, but in Venice and many other continental cities it is collected in underground reservoirs, and constitutes almost the sole source of fresh-water supply to the inhabitants. It is usually collected from the roofs of houses, and occasionally from paved or cemented ground. In hilly districts with deep ravines, it may be stored by carrying an embankment across a valley, or, in level districts, by digging a series of open trenches leading to a tank or reservoir.

The amount of water derivable from the rainfall in given cases is readily ascertained, if the mean annual rainfall of the district is known, and the dimensions of the receiving area are obtained. Thus, when the roofs of houses constitute the receiving area, the transverse section of the buildings will be one factor, and the mean annual rainfall the other. It has been estimated that the quantity which can be collected from the roof surface of any town in this country will scarcely amount to 2 gallons per inhabitant daily, assuming that the average rainfall is 20 inches, and that house accommodation gives a roof area of 60 square feet for each individual.

If lines be drawn through the sources of the tributaries of rivers marked on a map, they will be found to form the boundaries of certain areas which are called the catchment basins of the various rivers—that is the areas *which* receive the rainfall supplying their waters. In compact formations, where most of the rain runs off the surface, the ridge lines bounding these basins usually pass along the most elevated regions, but in porous formations their course will depend on the configuration of the retentive substratum.

The amount of rainfall which penetrates beneath the surface varies according to the density and configuration of the ground, and also depends on whatever influences the rate of evaporation. Thus, in loose sandy or gravelly districts, as much as 90 to 96 per cent sinks into the soil; in chalk districts, 42; in limestone, 20; while in districts of retentive, impermeable clay, the percentage is very small. Dr. Dalton, in his experiments on the new red sandstone soil of Manchester, found that 25 per cent of the whole rainfall penetrated to the depth of 3 feet; and Mr. Prestwich gave the amount of infiltration of the principal water-bearing strata surrounding London as varying from 48 to 60 per cent.

Other things being equal, the amount of infiltration will be far less in an undulating hilly district than in open, level plains. It is obvious also that it must vary very considerably with the season of the year. Thus, according to the experiments of Mr. Dickinson, made in the gravelly loam which covers the chalk in the valleys around Watford, it was 70 per cent in the first three months of the year; in the summer months it was only 2; while in November and December nearly the whole of the rainfall penetrated beneath the surface.

2. *Water from Wells, Springs, Rivers, and Lakes.*—The quality and composition of the water derived from these sources depend on the nature of the soil and geological strata through which it has passed, or on the character of its surface-bed or channel. The rain, already charged with carbonic acid in its passage through the lower regions of the atmosphere, becomes still more

largely impregnated with this gas when it sinks beneath the surface. In some rich soils, the amount present in the air contained within their interstices, according to Boussingault, is 250 times greater than the ordinary atmospheric ratio. Aided by the action of the carbonic acid which it has thus absorbed, the rain water dissolves and decomposes various chemical compounds which it meets with in its underground progress, and often becomes so highly charged with them as to become unfit for ordinary use, as in the case of mineral waters.

(1.) Surface or shallow well waters, though sometimes comparatively pure, frequently contain a large amount of organic matter. In mossy moorland districts, for example, or in rich vegetable soils, the water may contain from 12 to 30 grains of vegetable matter per gallon, which imparts to it a yellowish or brownish tint; while in marshy districts, the amount of organic matter varies from 10 to 100 grains. The saline constituents depend very much upon the geological character of the stratum in or upon which the well is sunk, but in inhabited places these are often masked by the products of excremental pollution. Shallow well waters are drawn from wells not more than 50 feet deep, and seldom exceeding half that depth. Surface waters from cultivated land are always more or less contaminated with manurial impurities, and should therefore be efficiently filtered before being used.

(2.) The water from deep wells and springs varies according to the geological strata through which it passes. Thus alluvial waters are more or less impure, containing a large amount of salts (20 to 120 grains per gallon), and often much organic matter; while the chalk waters are clear, wholesome, and sparkling, holding in solution a considerable amount of calcium carbonate besides other salts, and being largely impregnated with carbonic acid. *Also* wholesome and agreeable to the taste, but not so suitable for cooking purposes, is the water from the limestone and magnesian limestone strata. It contains more calcium and magnesium sulphate than the chalk water, and consequently does not become so soft on boiling. Waters from the granitic, metamorphic, trap-rock, and clay-slate formations, are generally very pure, and contain but small quantities of solids, consisting chiefly of sodium carbonate and chloride, with a little lime and magnesia. Waters from the millstone grit and hard oolite are also very pure. The saline constituents are by no means excessive, and are chiefly in the form of calcium and magnesium sulphate and carbonate, with traces of iron. Soft sand-rock waters, loose sand and gravel waters, and waters from the lias clays, vary very much in quality and composition, some of them being very pure, as the Farnham waters, and others containing large amounts of mineral and organic matters.

(3.) River water is in most cases softer than spring or well water. It contains a smaller amount of mineral salts, but is often largely impregnated with organic matter on account of the vegetable *débris* and animal excreta which find their way into it. Its constant movement, however, facilitates the oxidation of organic impurities, and this purifying process is aided to some extent by the presence of fresh-water plants.

(4.) Lake water, especially in mountainous districts composed of the older rock formations, is generally very soft, containing little mineral matter; but as it is essentially a stagnant water, and as all lakes receive the washings of the districts in which they are situated, the amount of organic nitrogenous matter is sometimes very considerable. Any excess, however, of peaty matter in solution may be materially lessened by filtering through sand.

As regards the qualities of potable waters founded upon their respective sources, the following classifications are given by the Rivers' Pollution Commissioners in their Sixth Report:—

I. In respect of wholesomeness, palatability, and general fitness for drinking and cooking:—

Wholesome.	1. Spring water.	Very palatable.
	2. Deep-well water.	
	3. Upland surface water.	Moderately palatable.
Suspicious.	4. Stored rain water.	
	5. Surface water from cultivated land.	Palatable.
Dangerous.	6. River water to which sewage gains access.	
	7. Shallow-well water.	

II. According to softness:—

1. Rain water.
2. Upland surface water.
3. Surface water from cultivated land.
4. River water.
5. Spring water.
6. Deep-well water.
7. Shallow-well water.

III. In respect of the influence of geological formation in rendering water sparkling, colourless, palatable, and wholesome, by percolation, the following water-bearing strata are given as the most efficient:—

1. Chalk.
2. Oolite.
3. Greensand.
4. Hastings sand.
5. New red and conglomerate sandstone.

SECTION II.—QUANTITY NECESSARY FOR HEALTH AND OTHER PURPOSES.

A healthy adult requires daily from 70 to 100 oz. of water for the processes of nutrition, about one-third of *which is* contained in articles of diet, the other two-thirds ing supplied in the form of liquids. The amount for oking has been estimated at from half-a-gallon to a llon daily for each person, while the quantity deemed cessary for personal cleanliness and for washing purses will necessarily vary very much according to the bits of the individual.

Dr. Parkes has given the following quantities used by man in the middle class:—

	Gallons daily.
Cooking	·75
Fluids as drink	·33
Ablution, including a daily sponge-bath	5
Share of utensil and house washing	3
Share of clothes washing	3
	12·08

The soldier is allowed about 15 gallons daily, no extra llowance being given for the women and children in a egiment. In the poorer districts of the city of London, r. Letheby found that the amount used was 5 gallons er individual daily, and in model lodging-houses, accordng to Mr. Muir, 7 gallons. In the cottages of the poor n country districts where water is scarce, the amount in any instances does not exceed 3 gallons, but then the nhabitants are not cleanly. A shower-bath daily will equire 3 to 4 gallons, while a plunge-bath will take from 0 to 60 gallons. Where water-closets are used, an dditional allowance of from 4 to 6 gallons must be proided. Latrines require a less amount.

In gross amounts Professor Rankine has given an stimate of 10 gallons daily per individual for domestic urposes, 10 for municipal purposes, and 10 more for rade purposes in manufacturing towns, and this amount, arge though it seems, is actually supplied to many towns t the present day. Glasgow, for example, receives 35 allons daily per head of population; Edinburgh and outhampton 35; Paris 31; and Liverpool 30. The different London water companies supply from 21 to 34 gallons, while the manufacturing towns in Lancashire and Yorkshire, according to Mr. Bateman, received from 16 to 21 gallons. Mr. Rawlinson's minimum estimate for manufacturing towns is 20 gallons per head daily, and if care be taken to prevent needless waste this amount will be quite sufficient. There is no doubt that a large proportion of the waste is connected with water-closets, and especially those which are directly flushed from the mains, and, as an instance in point, I may mention that when all such direct communication was cut off in the town of Warwick on my recommendation, the supply was reduced from 33 to 20 gallons per head daily.

In apportioning the daily allowance for all purposes, Dr. Parkes has given the following estimate:—

	Gallons per head of population.
Domestic supply	12
General baths	4
Water-closets	6
Unavoidable waste	3
Total house supply	25
Municipal purposes	5
Trade purposes	5
Total	35

No doubt this estimate may be regarded as somewhat excessive, especially in the items of domestic and water-closet supply, but it has been based on the principle that a liberal allowance is not only necessary for thorough cleanliness, but that it is also required for an efficient clearage of sewers. There can be no question, however, that the amount of water habitually wasted in many towns is enormous, reaching in all probability to at least one third of the supply, and this, when the water has to *be pumped* into the town, or when the town sewage has be pumped or chemically treated in any way at the fall, increases the rates to a very considerable extent. ile part of this waste is due to underground leakage n pipes and mains, by far the larger portion of it is to imperfect household fittings, and to carelessness in ving stool-cocks and bib-cocks open in connection with ter-closets whose flush pipes communicate directly with mains. All closets should be provided with cisterns the waste-preventing class, but of sufficient capacity to sh the closet-pan when used.

For hospitals the daily amount per patient may be imated at about 30 gallons. In prisons and work-uses the quantity will vary according to the bathing rangements, and whether water-closets are used. In e Convict Prison, Portsmouth, where water-closets and ater-latrines are both in use, and where each prisoner is lowed a general bath once a week, I found that the nount averaged about 11 gallons per convict daily.

SECTION III.—MODES OF SUPPLY.

This part of the subject has reference to wells, borings, e collection and storage of water, and to water-works nerally.

1. *Wells and Borings.*—In small urban and rural istricts surface wells, whether as ordinary pump wells, aw wells, or shallow dip wells, constitute the usual urce of supply, and though they may naturally yield a holesome water, the surrounding soil often becomes so turated with impurities that it is next to impossible to revent their pollution. In crowded localities, therefore, hey should always be regarded with suspicion, and, as far s possible, their use should be discontinued. Deep wells, n the other hand, are not open to this objection, because hey are generally sunk through an impervious stratum,

which prevents the infiltration of any surface impurities, and at the same time serves to keep down the water in the porous strata beneath. The quality of the water from these wells, as has already been shown, will depend on the nature of the geological formation of the district. It is also apparent that, in accordance with a well-known physical law, it is only necessary to bore through the impervious stratum, and reach the water-bearing bed, for the water to rise to the surface, or to within a short distance of it, so as to be collected in a well of ordinary dimensions. Indeed, in certain low-lying districts, where a boring is made at a point considerably below the level of the line of infiltration into the water-bearing stratum, the water rises above the surface and overflows. Such overflowing wells, or artesian wells, as they are called, were once common in the valley of the Thames, and are still to be met with in the flat lands of Essex and on the coast of Lincolnshire. Ordinary borings differ from artesian wells in not piercing through a retentive stratum in order to reach the water-supply. They are very common in the chalk and new red sandstone districts, and are made to increase the yield of the wells. Practically, it is found that one boring adds to the supply of a well nearly as much as several. Thus in the Bootle well at Liverpool, with 16 bore-holes, some of which were 600 feet deep, Mr. Stephenson found that when all were plugged up but one, the yield was 921,192 gallons per day, and when all were open it was only increased by 112,792 gallons.

Deep wells are now being abandoned for the supply of large towns, because they are found to be insufficient for the wants of a rapidly-increasing population, and obviously cannot be multiplied within a given district beyond certain limits, because every single well drains a surrounding area of some considerable extent. For large isolated buildings, however, such as lunatic asylums, workhouses, and prisons, they usually supply the whole of the water required; and in selecting a site in the country for any such building, the possibility of obtaining the requisite water-supply, and the cost at which it can be procured, are points of the first importance.

Generally speaking, the chance of obtaining a good supply will depend upon the nature of the underlying strata, and upon the level of the proposed site. Wells sunk in superficial sand or gravel beds, though yielding a good supply at ordinary times, are very liable to have their yield very much lessened in seasons of drought, unless they are situated at points considerably below the level of the surrounding country, and the same remark applies to surface wells in the chalk districts. On the other hand, deep wells or borings in the new red sandstone, and oolite or chalk formations, usually yield a large and constant supply, because these permeable rocks are so saturated with water that they may be regarded as vast subterranean reservoirs. The deepest artesian wells in the world are those at Grenelle in Paris and Kissengen in Bavaria, the former being 1800 and the latter 1878 feet in depth.

The Commissioners, in the report already alluded to, strongly urge "that preference should always be given to spring and deep well water for purely domestic purposes, over even upland surface water, not only on account of the much greater intrinsic chemical purity and palatability of these waters, but also because their physical qualities render them peculiarly valuable for domestic supply. They are almost invariably clear, colourless, transparent, and brilliant, qualities which add greatly to their acceptability as beverages; whilst their uniformity of temperature throughout the year renders them cool and refreshing in summer, and prevents them from freezing readily in winter. Such waters are of inestimable value to communities, and their conservation and utilisation are worthy of the greatest efforts of those who have the public health under their charge."

The following are some of the towns which are supplied by deep wells:—Canterbury, Cambridge, Bury St. Edmunds, and Deal, from the chalk formation; Birkenhead, Coventry, Leamington, and Southport, from the new red sandstone; and Bedford and Scarborough from the oolite.

For a small or temporary supply the American tube well (Norton's patent) has been found to be very useful. It consists of a narrow iron tube driven into the ground in lengths, the lower part being pointed and perforated at its end, and is fitted with a single or double action pump according to the depth. The water enters the tube through the perforations, and, if the bed is sandy, has to be filtered for some time, until, by gradual removal of the sand, a well is formed around the lower end, and the water is obtained without sediment. This pump is especially adapted for country districts, and it possesses the further advantage of helping to keep out surface impurities.

In order to ascertain the yield of surface wells, the water must be pumped out, and the time noted which is required for refilling. The yield of small springs can be readily measured by receiving the water into a vessel of known dimensions, such as a cask, and also noting the time which it takes to fill.

2. *Water-Works.*—In addition to deep wells, water-works on an extensive scale obtain their supply from lakes, streams, rivers, or gathering-grounds. If from a lake of sufficient elevation above the level of the town to be supplied, the water may be distributed throughout the town in conduits and pipes by the force of gravity. When the source of supply is a stream or small river,

storage works are necessary; but when the river is large, a constant supply can be obtained at all times, independently of storage. In this case, the works required usually comprise—a weir or dam for maintaining part of the river at a nearly constant level; two or more settling-ponds, into which the water is conducted; filtering apparatus, and pumping engines.

When it is required to ascertain the yield of any small stream, it is usual to employ a weir-gauge to dam up the water into a pond behind, and allow it to flow through a sluice or over a sill of known dimensions. In the case of an average-sized stream, a rough approximation of the yield may be obtained by taking the breadth and depth at several distances in a short section of the channel which is tolerably uniform, and thus ascertaining the average sectional area. The surface-velocity may then be taken by noting the time occupied in floating a light object over the selected distance, and as four-fifths of the surface-velocity are about equal to the actual velocity, the yield in cubic feet or gallons per second can be easily calculated.

When the water-supply of a town is collected from small streams or gathering-grounds, the rainfall of the catchment basin and its available amount are items which ought to be carefully inquired into. The ratio of the available to the total rainfall, as already shown, is influenced by the nature of the soil, the steepness or flatness of the ground, the rapidity of the rainfall, and other circumstances. Professor Rankine has given the following examples:—

GROUND.	Available Rainfall divided by Total Rainfall.
Steep surfaces of granite, gneiss, and slate,	nearly 1
Moorland hilly pastures . .	from ·8 to ·6
Flat cultivated country . .	from ·5 to ·4
Chalk	0

The average annual rainfall in different parts of this country varies from 22 to 140 inches, the least recorded depth being 15 inches. It is greater in mountainous than in flat districts, and on the leeward side of a mountain ridge than it is on the side facing the prevailing winds. As regards water-supply, the most important data are the least annual rainfall and the longest period of drought.

In selecting drainage areas, it must be borne in mind that the nearer the actual rainfall water is collected, the freer it will be from impurities, and that purity of water and fertility of soil are not to be expected together. Water collected from a peaty soil will contain large quantities of vegetable matter, while that from a soil well cultivated will be tainted with animal impurities. The purest water, therefore, which can be collected from drainage areas is found in the barren moorland districts of the primary geological formations, or of the sandstone rocks.

The channels of the gathering-ground may either be the natural watercourses of the district, or these may be supplemented by adits, closed drains, or open ditches. The latter, however, are objectionable because they form receptacles for vegetable matter, and as the current in them must be necessarily slow, there is considerable loss by evaporation. The position, extent, and dimensions of the adits leading to the reservoir will depend upon the configuration of the district. The reservoir itself is generally a natural hollow, situated in the valley-line of the catchment basin, and of sufficient elevation to procure a fall, so that the water can be distributed without mechanical means being required to raise it. In this country the storage-room should be large enough to contain a four or six months' supply; and the site which can supply the requisite storage-room with the least embankment, the least amount of puddle, and the least area laid under water is to be preferred.

Upon the strength and stability of the embankment everything depends. It is made water-tight by a core of clay puddle, the inner slope being protected from the action of the water by a pitching of dressed stones, and the outer, from the effects of the weather by a covering of grass sods. The puddle-core generally amounts to a tenth of the whole embankment. The height of the embankment varies from 3 to 10 feet above the highest water-level, the top being covered with broken stones. No trees or shrubs are allowed to grow upon it, and the greatest care is taken in its construction, to prevent animals, such as water-rats, burrowing into it.

Every impounding reservoir, as it is called, is provided with an overflow weir to permit the discharge of the flood supply from the drainage area, and this is often supplemented by a channel termed the *bye-wash,* which is used to divert the streams supplying the reservoir, so as to prevent fouling of the store-water. The flood-water carried off in this way flows into the natural watercourse.

In order to remove the sediment which collects in the bottom of the reservoir, there is always a cleansing pipe as well as a discharge pipe, the former being on a level with the lowest point in the reservoir, and discharging into the natural watercourse below the embankment. Both are carried through a culvert in the embankment, which is built of stone or brick, and founded on the solid rock. The aqueduct or discharge pipe bends upwards in the reservoir, and has a series of inlets, the lowest at the lowest working level, and the whole of them guarded against the entrance of small stones, pieces of wood, or other bodies, which would interfere with the action of the valves. The sluices, which are required for both pipes, are situated in the reservoir, and are worked from the sluice-tower.

The aqueduct is that portion of the conduit leading from the reservoir to the distributing conduits. It may be open or close throughout, or partly close and partly open. If close, it generally consists of a train of cast-iron pipes securely jointed, bedded on a firm foundation, and covered to a depth of at least 2 or 3 feet, to preserve them from frost. Sluice stop-cocks are provided in the valleys, for the purpose of scouring out any stones or sediment, and, at intervals not exceeding half a mile, to permit of repairs. Valve-cocks are supplied at all the principal summits, to allow the escape of air. When the aqueduct is partly close and partly open, or if, when close, it cannot withstand the whole pressure when the demand ceases, either a system of weirs is required to discharge the surplus water, or a second store-reservoir is provided, resembling, in general plan and construction, the impounding reservoir.

The distributing conduits also consist of cast-iron pipes, and are coated, like the aqueduct pipes, with pitch, or Dr. Angus Smith's varnish, to preserve them from corrosion. The same details with regard to sluice-cocks and stop-cocks are observed in the different bends of the tracks, with this addition, that the dead ends or terminations of the branch and main conduits are supplied with scouring valves, through which stones and sediment can be washed. In wide streets, or in streets with much traffic, there is generally a service-pipe for each side, in order that the house-pipes may be as short as possible, and may be accessible without disturbing the traffic. The house service-pipes are usually made of lead, and though they are liable to be acted upon by some waters, the readiness with which they can be adapted to all the bends and curves rendered necessary in carrying the piping to lifferent floors of houses, gives them a preference to all ther kinds of metal pipes. The waters which act most n lead are the most highly oxygenated, and those which ontain organic matter; those which act least on it conin carbonic acid, calcium carbonate, and calcium phoshate. Polluted shallow well-waters are especially angerous in this respect, because they act on it violently nd continuously, and hence leaden pump pipes should ever be used. Various means have been proposed to rotect the lead from corrosion, such as coating with bituinous pitch or with coal tar; but when the quality f the water renders lead pipes objectionable, cast nd wrought iron pipes make the best substitutes, or he composite cylinder pipes manufactured by Messrs. Walker, Parker, and Co. These pipes consist of a separate tube of pure block-tin encased in lead, and the union of the two is so perfect that no amount of torsion will separate them.

As the greatest hourly demand for water is about double the average hourly demand, the main conduits supplying a town must have double the discharging capacity which would be required if the hourly demand were uniform. The additional expense in piping which would be thus entailed is sometimes so great, that distributing basins or town-reservoirs are constructed to supply certain districts. To meet all emergencies, they are made large enough to contain at least a day's supply, and they must also have a site of sufficient elevation to ensure distribution by hydrostatic pressure. Every such reservoir should be roofed in and ventilated, to protect the water from frost and heat, and from becoming tainted with aerial impurities.

The water thus distributed to the various houses in a district is supplied either on the intermittent or constant system. The intermittent system necessitates storage in house cisterns, and is attended by so many disadvantages, that the constant system should always be adopted wherever it can be carried out. The use of cisterns, except on a small scale, for water-closets and boilers, is open to the great objection of the risk of contamination of the water, for not only are the cisterns liable to become fouled if not sufficiently protected against the entrance of aerial impurities, but the water is apt to become tainted with sewer-gases, which may enter the cistern through the overflow pipe. Moreover, in poorer districts, the cisterns are often of a very inferior description, are badly situated, and are seldom inspected or cleaned out. To meet this objection, it has been proposed to have one large tank for the supply of a group of houses,—the tank to be under the immediate inspection of the water-work officials, and to be filled daily, and the householders to be supplied through small pipes constantly charged. It is further urged against the intermittent system, that the distribution pipes, being alternately wet and dry, are liable to collect dust and the effluvia from sewers or drains. The objections to the constant system, on the other hand, are the great waste when the fittings are imperfect, and an insufficient delivery when the water-supply is not abundant. The diameters of the pipes for constant service should therefore be carefully adapted to their discharges and to the head of pressure; the drawing taps ought to be valvecocks to open and shut with a screw; and the town should be efficiently provided with distributing basins, so that an extra flow of water in one district would not interfere with the requisite supply of other parts. With proper fittings, strict regulations, and efficient supervision, it is now clearly established that a constant supply requires a less amount of water than an uncontrolled intermittent supply, so that even on the score of economy the constant system is to be preferred.

In order to prevent undue waste, water-meters are sometimes applied to the service-pipe supplying a group of houses, and the landlord charged for the amount used; but as this plan induces the landlord to enforce a too rigid economy, it is not to be commended. The best water-meters are capable of registering exactly all amounts exceeding a flow of one gallon per hour; but when the water contains a considerable amount of undissolved impurities, and is badly filtered, they very soon become clogged up and fail to register anything like the quantity of water which may pass through them.

The waste-preventer, or small cistern for the supply of water-closets, which has already been alluded to, should at least hold 2 gallons. The smallest waste-preventers hold $\frac{3}{4}$ of a gallon, but this quantity is insufficient to flush the pan and soil-pipe properly.

Another plan for effecting economy in the constant system, proposes that a cistern, large enough to hold a twenty-four hours' supply, be provided for each house, and that the service-pipe shall be of a diameter to deliver the required quantity during that time, and nothing more. Every cistern supplied in this way would become gradually emptied during the day time, and would be refilled during the night; but the plan is open to the great objection attaching to the intermittent system, and does not sufficiently provide for emergencies.

Wherever cisterns are employed, they should be so situated that they can be readily cleaned out when necessary. The best materials for their construction are slate-slabs well set in cement, or galvanised iron. Leaden cisterns, unless lined with a coating of pitch, tar, or other preservative substances, are objectionable. All cisterns should be covered in, and protected from heat and frost. The inlet to every cistern ought to have a cock, with a float to rise and stop the supply when the cistern is full;

and when the supply is constant, the overflow should be so arranged as to become troublesome if not immediately rectified. An overflow pipe from a cistern should never lead directly into a soil-pipe, sewer, or drain, but should end above ground over a trapped and ventilated grating. If this were always attended to, no sewer-gases could find their way to the cistern through this channel.

In addition to the arrangements for domestic supply, outlets or hydrants with valve-cocks are provided on the service-pipes of all large towns, at regular intervals, in case of fire, and for supplying water to flush the gutters and water the streets.

In laying down water-pipes and mains, it is of great importance that the separation between them and sewers, drains, or gas pipes should be as wide as possible. Whether the water-supply be on the constant or intermittent system, the risk of suction of gases or fluids into leaky mains is imminent, though of course much less when the supply is constant. Unfortunately, however, this danger of contaminating public water supplies has hitherto not been appreciated, and indeed in many towns, as for example in Croydon, it has been enhanced by arrangements for flushing sewers directly from the mains.—(See Mr. Simon's *Reports*, New Series, No. VII.)

SECTION IV.—PURIFICATION OF WATER.

On an extensive scale the process of purification is carried on by means of filtration, the water being received into large filter-beds previous to its distribution. A filter-bed may be described as a tank or reservoir several feet in depth, with paved bottom, on which are laid a series of open-jointed or perforated tubular drains leading into a central culvert. The drains are covered with a layer of gravel about 3 feet deep, over which is spread a layer of sand about 2 feet deep. The layer of gravel is coarse at the bottom, becoming gradually finer towards its upper surface, and the same relative gradation, as regards coarseness and fineness, is observed with regard to the sand. The water is delivered uniformly and slowly, and in order that the filtering process may not be carried on hurriedly, the pressure is always kept low, the depth of water being seldom above 2 feet, and in some cases only 1 foot. The speed of vertical descent should not be much above 6 inches per hour, nor should the rate of filtration much exceed 700 gallons per square yard of filter-bed in the 24 hours, although some water companies filter at a much more rapid rate than this. In large works there are always several filter-beds, to allow of some being cleansed while the others are in use. The sediment deposited on the surface of the sand requires to be scraped off at intervals, and at each cleansing operation about half-an-inch of sand is also removed. A fresh supply of sand is added when the depth of the layer is reduced to an extent which threatens to impair the efficiency of the filter. It appears that proper filtration, carried on according to this plan, removes suspended impurities, and a certain amount of dissolved mineral substances, but whether dissolved organic matters are destroyed, or oxidised to any considerable extent, seems doubtful.

Small filters for domestic use may be placed in the cistern, in the course of the delivery pipe, or they may be filled by hand. As filtering media various substances are used, such as animal or vegetable charcoal, a mixture of fine silica and charcoal, magnetic carbide of iron, sponges, wool, etc. According to Dr. Parkes, the best filters are made either of animal charcoal or magnetic carbide of iron. They are capable of removing almost all the suspended matters, and at least 40 per cent of dissolved organic impurities, together with a considerable amount of salts, such as calcium carbonate and sodium chloride. Indeed, the experiments of Mr. Wanklyn with the silicated carbon-filter prove that, by repeated filtration, river water containing a considerable amount of free and albuminoid ammonia may be made as pure as deep spring water.

Of filtering media, animal charcoal, properly washed, is now admitted to be in every way the most efficient, but it should be frequently renewed. It exerts a chemical as well as mechanical action on organic impurities, and Dr. Frankland is so convinced of its value as a filtering agent, that he recommends its employment on a large scale for the purification of town supplies, in spite of the cost which would be entailed. Professor Bischof has also discovered that spongy iron possesses remarkable purifying properties, which have been fully confirmed by the experiments of the Rivers' Pollution Commissioners, and it may here be stated that the spongy iron filter received the medal of the Sanitary Institute two years ago for its general excellence.

Amongst other filters which have been commended for their efficiency, may be mentioned the cistern filter of the Water Purifying Company, London; Lipscombe's Self-Cleaning Charcoal Filter; the Patent Carbon Block Filter, manufactured by Atkins and Co., London; the Carbon Cistern Filter, planned by Mr. Finch, of the Holborn Sanitary Works; and the various filters devised by Halliday and Co., of Manchester. All of these contain animal charcoal as the filtering medium, and can be applied to any kind of house cistern. The filtering block of the Silicated Carbon Company consists of 75 per cent of charcoal and 22 of silica, with a little iron oxide and alumina. It is cemented into a vessel which it divides into two chambers, the one containing the filtered and the other the unfiltered water. This filter is found to work *very efficiently*, and with a little care retains its properties for a long time. The filtering material of the Magnetic Carbide Filter is prepared by heating hæmatite with sawdust, and has all along been highly commended. The Patent Moulded Carbon Filter makes an elegant article for the sideboard. It consists of two glass vessels, the upper containing the filter-block, and the lower, which can be used as a water bottle, the filtered water. Tap-filters, suited for a high or low pressure, can be fitted to the pipes themselves. They contain charcoal or silicated carbon, and would seem to act very well. Mr. Bailey Denton's "Self-Supplying Ærated Filter" is placed beneath the house-cistern, and by a simple arrangement of valve-cocks as much water is supplied to the cistern as is removed from the filter every time water is drawn off.

A charcoal filter has been introduced by Major Crease, of the Royal Marine Artillery, which, for simplicity of construction, adaptability to different kinds of water and rates of supply, and for efficiency, deserves special notice. It is now largely used in the Navy, and is specially suited for large buildings, such as asylums, workhouses, etc. The tank is made of iron, lined with cement, and the whole of the apparatus can be readily unscrewed, taken to pieces, and cleaned out when necessary, the joints being made water-tight by gutta-percha bands. Dr. Bond of Gloucester has recently devised a very efficient filter known as the Patent Floating Feed Filter. By means of a floating feeder, the water entering the filter is always taken from the surface, so that any sediment is prevented from entering the filtering material, which consists of animal charcoal. The action of the filter is intermittent, thereby ensuring a maximum of oxidising power, and it possesses the further advantage of being easily cleansed. Dr. Bond has also devised a very cheap filter which acts very well, called the Floating Syphon Filter. It consists of a hollow metallic vessel placed in a jar, tub, or other convenient vessel and from which it will filter the water at the rate of from one to several gallons a day. It can be readily regulated and cleaned; and as any suspended impurities are kept outside the filter and allowed to gravitate towards the bottom of the containing vessel, it is not liable to become clogged up. Pocket Syphon Filters are made of hollow blocks of charcoal with a tube passing into the cavity, into which the water filters through the charcoal.

All filters after a time become clogged up, and have therefore to be taken to pieces and thoroughly cleansed; or, if this cannot be easily done, they may be purified by passing through them a solution of potassium permanganate or Condy's fluid, with the addition of a few drops of strong sulphuric acid, and afterwards two or three gallons of pure or distilled water, acidulated with hydrochloric acid. The charcoal in a filter may also be purifie by exposing it for some time to the sun and air, or b heating it in an oven or furnace. In the spongy iro filter, the filtering medium has to be renewed from tim to time.

The purification of water without filtration is no carried on in this country on the large scale except b Dr. Clark's process. This consists in adding a certai amount of lime water to a water which contains calciu carbonate rendered soluble by the presence of carboni acid. Spring waters in the chalk districts are all mor or less "hard," and many of them contain such a larg amount of calcium carbonate in solution, as to be unfi for washing purposes. Such a water, when it is to b rendered "soft" by Clark's process, is let into a tank reservoir, where it is mixed with a proper proportion lime water and allowed to settle, the whole of the calciu being precipitated as calcium carbonate. A perfectl [illegible] and wholesome water is thus obtained, well suit for domestic purposes. Calcium carbonate may also be removed by boiling, in which case it is deposited as an incrustation on the inner surface of the kettle or boiler. What is known as the "Porter-Clark Process" is a modification of Clark's process, which, at the same time, provides for very efficient filtration.

Aluminous salts have long been used in Eastern countries to purify water, and are found to be very efficacious in removing suspended matters, whether organic or mineral. Organic matters in solution are best treated with potassium permanganate or Condy's red fluid. It readily removes any offensive odour arising from water kept in casks, and oxidises at least a portion of the organic impurities which may be present; but as albumen is only slightly affected by it without the aid of heat, it cannot be regarded as a reliable purifier of water tainted with animal impurities. Suspicious waters should always be boiled before being used.

Among other purifying agents may be mentioned, distillation, the exposure of water in minute divided currents to the air, the immersion of pieces of charcoal or of iron wire, and the effects of plants and fish. In store reservoirs, the presence of a moderate quantity of living plants exerts a decidedly purifying influence, while the destruction of fish has been followed by an excessive multiplication of the small crustacean animals on which the fish had lived, thereby rendering the water nauseous and impure. The remedy was found in re-stocking the reservoir with fish.—(*Rankine.*)

SECTION V.—SOURCES OF POLLUTION.

Although reference has already been made in the preceding remarks to various ways in which drinking water becomes polluted, it will be expedient to consider this important part of the subject somewhat more fully in detail; and first with regard to the water-supply of rural and small urban districts.

Estimating the town population of Great Britain at about fifteen millions, the Rivers' Pollution Commissioners observe that "the remaining twelve millions of country population derive their water almost exclusively from shallow wells, and these are, so far as our experience extends, almost always horribly polluted by sewage, and by animal matters of the most disgusting origin. The common practice in villages, and even in many small towns, is to dispose of the sewage and to provide for the water supply of each cottage, or pair of cottages, upon the premises. In the little yard or garden attached to each tenement, or pair of tenements, two holes are dug in the porous soil; into one of these, usually the shallower of the two, all the filthy liquids of the house are discharged; from the other, which is sunk below the water line of the porous stratum, the water for drinking and other domestic uses is pumped. These two holes are not unfrequently within twelve feet of each other, and sometimes even closer. The contents of the filth hole or cesspool gradually soak away through the surrounding soil, and mingle with the water below. As the contents of the water hole or well are pumped out, they are immediately replenished from the surrounding disgusting mixture, and it is not therefore very surprising to be assured that such a well does not become dry even in summer. Unfortunately, excrementitious liquids, especially after they have soaked through a few feet of porous soil, do not impair the palatability of the water; and this polluted liquid is consumed from year to year without a suspicion of its character, until the cesspool and well receive infected sewage, and then an outbreak of *epidemic* disease compels attention to the polluted water.

ndeed, our acquaintance with a very large proportion of
is class of potable waters has been made in consequence
f the occurrence of severe outbreaks of typhoid fever
nongst the persons using them."—(See *Sixth Report.*)

Although it can scarcely be said that this description
pplies to rural districts generally, there can be no doubt
at it correctly represents the condition of the water
pply of a vast number of villages and scattered country
ouses. Cesspools, cesspits, or drains, in close proximity
wells, are a fruitful source of mischief; and so also
re midden-heaps or deep ashpits connected with privies,
nd the huge manure heaps which are allowed to accumu-
te in farmyards. All such collections of liquid or solid
lth should be regarded as dangerous nuisances, and
hould either be done away with altogether, or such
dequate precautions taken as will obviate the risk of
oakage into the well. The substitution of a dry system
f conservancy and the use of pails or boxes for the cess-
ool, common privy, and cesspit, together with better
cavenging, would lessen to a very large extent the
langers of well-pollution in country districts; but in
rowded localities the soil becomes so saturated with filth
f all kinds, that surface wells are never safe. All pump
ells should be clay-puddled to a depth of eight or ten
eet, to keep out surface impurities; and instead of
raw wells or shallow open dip wells, which are especially
iable to pollution, either proper pump wells should be
rovided, or where the nature of the subsoil is suitable,
orton's tube wells would be found to possess many
dvantages. Surface wells near graveyards are very often
ound to be polluted.

But even when there is no drain or cesspool near, a
well frequently becomes polluted because it is never
cleaned out, and for my own part I regard this periodic
cleansing of wells so necessary, that I think every pump

well should be provided with a manhole and be cleaned out at stated times. In towns or large villages provided with a public water-supply, the closing of all surface wells, whether public or private, should be rendered compulsory; for, with drains ramifying in every direction, it may be taken for granted that they are either polluted, or are at all events constantly liable to pollution.

With regard to public supplies, it may be stated generally that water may become polluted either at its source, in the course of distribution, or through defects connected with its storage. Any supply, as for example a large part of the London supply, which is taken from a river polluted by the sewage of towns up-stream, must be carefully filtered, and even then it can only be regarded as a suspicious water. Deep wells or springs, on the other hand, may become polluted by the entrance of surface impurities, or by the access of polluted water through open fissures in the rock. But perhaps the most frequent and insidious sources of pollution to which public supplies are exposed, are those dependent upon the arrangements for distribution and storage. It has already been pointed out that with an intermittent supply the mains must necessarily become full of air when the water is turned off, and if at all leaky, as they very often are, they may become charged with liquid as well as aerial impurities. Moreover, when water-closets are served direct from the mains by mere taps or stopcocks, there is always the danger of liquid filth being sucked into them whenever a closet-pipe becomes choked up, and the pan becomes full. The following experiment will illustrate how readily such pollution may occur:—In the report on Croydon already referred to, Dr. Buchanan states that he had a common house tap connected with a pan containing solution of burnt sugar sufficient to colour some thousand gallons of water, and that in the ordinary ight-intermission of supply, the whole of this was raightway sucked into the pipes, and except from one eighbour, was no more heard of. He also adds that iere is an instance on record of bloody water coming om the main tap of a house situated next to a slaughter-ouse. Then, too, connected with this system of interittent supply, there are all the risks of contamination ttaching to cisternage, or storage in pails, butts, or other eceptacles. If the same cistern is used to supply the ouse and the water-closet as well, sewer-gases from he closet have access to the surface of the water in the istern; or should the overflow-pipe from the house istern discharge direct into a sewer or drain, there is of ourse the same danger. Apart also from the risk of lead-ollution from leaden-cisterns, the water stored in a istern may eventually become unfit for use, because the istern is seldom or never cleaned out.

But even with a constant supply there appear to be ertain dangers depending upon possible in-currents from leaky mains, especially when these are in juxtaposition to sewers or drains, which have hitherto escaped the otice of engineers. The physical conditions under which such in-currents may take place, have been inestigated to a certain extent by Dr. Buchanan, and I uote his results here, in order that others may be induced o make experiments in the same direction. In a note ppended to the Croydon report he gives the following ummary of results:—"I find (1) the lateral in-current s freely produced when the water-pipe is descending, and when the pipe beyond the hole is unobstructed; (2) if he force of water-flow in a descending pipe be moderate, moderate degree of obstruction beyond the hole does not prevent the in-current; (3) in horizontal pipes of uniform calibre, when the flow is strong, or the pipe beyond the hole is long, or when the end of the pipe is at all turned upwards, the in-current does not take place, but (4) momentary interference with flow *a tergo*, or momentary reduction of obstruction *a fronte*, allows of a momentary in-current through the hole; (5) in-current through a lateral hole takes place with incomparably greater ease when the hole is made at a point of constriction of the water pipe."

It has further to be observed that water mains, if not sufficiently protected against corrosion, may render the water turbid, owing to rusting of the iron; that the tow or gaskin employed to caulk joints may taint the water for a long period if the main is several miles in length; and that leaden pipes, especially when first laid down, may become a source of danger if the water is soft.

With regard to the general effects of drinking impure water, and particular outbreaks of disease depending upon ascertained sources of pollution, see Chapter VIII.

CHAPTER VII.

WATER ANALYSIS.

SECTION I.—COLLECTION OF SAMPLES.

collecting water for analytical purposes, and parti-
larly when it is intended to submit samples to a
antitative analysis, the following directions should be
served :—An ordinary glass-stoppered Winchester quart
tle will answer very well for the conveyance of the
ter. It should be cleaned out with strong sulphuric
d, then rinsed with ordinary good water until the rinsings
no longer acid, and finally washed out with some of
water to be examined. The bottle should be filled
ost up to the neck, stoppered, and the stopper covered
r with a piece of clean calico, wash leather, or gutta
ha tissue, tied, and sealed. No luting should be
d except sealing-wax, and even that should be dis-
sed with if possible. If the water contains organic
ter, it should be examined at least within forty-eight
rs after being collected.

In collecting pond or lake water, the bottle should be
nged into the water as far as possible from the bank,
h the mouth well under the surface, so as to avoid the
m, care being taken, at the same time, that the mud
the bottom is not disturbed. If the sample is taken
m a town supply, it should, if possible, be collected
ect from the mains, or from the water-jets at the cab-
nds or public fountains, in which case the water should

be allowed to flow for some time previous to filling t bottle. If taken from a house service-tap, the wat should also be allowed to flow for some time before co lecting. With regard to river water, it is recommende to select the middle of the stream, to avoid the outlets o sewers and feeders, and to note whether there has bee previously a heavy fall of rain or a long drought. Whe a sample is required from the source of a spring, it i sometimes necessary to dig a small excavation and allow all sediment to subside before the sample is taken. Well-water should of course be drawn direct from the well.

Different methods of examination require different quantities; for Mr. Wanklyn's method one Wincheste quart will be quite sufficient, but for a complete investigation some analysts require about a gallon. If a Wincheste quart cannot readily be procured, a clear glass wine bottl will answer very well, but care must be taken to have i thoroughly clean, and the cork should be clean and new and fit well.

The medical officer of health will find it very convenient to have a basket containing two or more clea glass-stoppered bottles placed under the charge of th sanitary inspector of the district. The basket should b provided with a padlock fitted with two keys, one of whic should be in the possession of the medical officer of health and the other retained by the inspector. Before forwarding the bottles, the inspector should affix a label to each containing the date and a distinctive number, or certai particulars with regard to the source of the water an why it is suspected. For ordinary analysis pint stoppere bottles will be found to be large enough, because, shoul a greater quantity be required at any time, two bottle can be used instead of one.

SECTION II.—PHYSICAL EXAMINATION.

A portion of the sample collected should be poured, after shaking the bottle, into a good-sized clear glass flask. If the flask is then held in front of a dark-coloured surface, with a good light falling on the side or from above, any suspended impurities will become visible, but care should be taken to discriminate between them and air-bubbles.

Colour and turbidity are best ascertained by pouring the water into a tall vessel of colourless glass, and placing it upon a porcelain slab or piece of white paper. Another glass of the same dimensions, filled with distilled water, should be placed by its side for comparison. Both samples are then looked through from above, and the difference between them noted. If organic matter is present, the water has usually a tinge of yellow, green, or blue, but mineral substances may give similar indications. Clay, peat, and other harmless contaminations impart a brownish tint. If the turbidity is considerable, or if the water is very dark in colour, it may be pronounced unfit for use, although filtration may render it perfectly wholesome.

To observe the smell of the water, a portion of it should be poured into a wide-mouthed flask, making it about one-third full, and then shaking it well. If the smell is unpleasant, the water is unfit to drink. Should no smell be detected, the flask should be heated, and the water again shaken, and if there is still no smell, a little caustic potash should be added to the warm water. Any unpleasant odour which may now be given off indicates with tolerable certainty that the water contains organic impurities in considerable quantity. The occurrence of a precipitate on the addition of the caustic potash will, at the same time, indicate hardness.

With regard to taste, it is sufficient to say that a badly tasting water should be condemned for drinking purposes. Many waters, however, which are largely impregnated with dissolved animal impurities may be quite palatable.

Altogether, the physical examination of water is of a negative character; and although it may impart some useful information, it cannot be relied upon in arriving at a sound conclusion as regards the good or bad qualities of any given sample.

SECTION III.—MICROSCOPICAL EXAMINATION.

In order to collect the sediment, the water should be allowed to stand for 12 or 24 hours. Particles of sand are recognised by their angular shapes, and by their not being affected by acids. Particles of clay and marl are amorphous, and are also unaffected by acids. Particles of chalk are amorphous, and are readily dissolved by acids. Dead vegetable matter, such as woody fibre and portions of leaves, and living vegetable matter, consisting of confervoid growths, may all be detected in water which cannot be pronounced unwholesome. So also may *diatomaceæ*, *infusoria*, and *entomostraca*. Microscopical examination, therefore, is only valuable for practical purposes, in so far as it indicates the various components of the suspended matters; it gives no direct information concerning the presence of dissolved organic impurities. There is no doubt, however, that it presents a wide and interesting field for research, and in this respect the writings of Drs. Burdon Sanderson, Cohn, and Macdonald of Netley, are extremely valuable.

SECTION IV.—CHEMICAL EXAMINATION.

This may be either qualitative or quantitative. For *ordinary* purposes, as, for example, in the discharge of a medical officer of health's duties in rural districts, a qualitative examination, if judiciously conducted, will be found to be quite sufficient to enable him to give a reliable opinion as to whether a water is fit for use or not in the great majority of instances. But, in all cases in which qualitative tests indicate that a water is doubtful or suspicious, and in cases which are likely to lead to magisterial proceedings, it is necessary to submit the sample to a quantitative analysis more or less complete. A quantitative analysis is also required in the examination of public supplies, and in the case of any proposed new public supply, it should be thorough in all its details.

But the main object which the sanitarian has in view is to determine whether or not any given water is dangerously contaminated with organic matter, and this, as I have already said, may be ascertained in the great majority of instances by a qualitative examination. After noting the various indications obtained from the physical examination previously described, and taking care that all test-tubes, test-glasses, measures, and the like, are thoroughly clean and conveniently arranged, the qualitative testing of one or more samples may be readily conducted as follows :—

1. *Qualitative Examination.*

(1.) *Ammonia.*—Fill an ordinary test-tube of about 1 oz. in capacity nearly full with the water to be examined, and add 3 or 4 minims of the Nessler reagent. If a yellow or brown colour, or a brownish precipitate, be produced, the water contains ammoniacal salts. As a rule, this should be regarded as a very suspicious circumstance, and should the coloration be well marked, it is almost sufficient of itself to condemn the water for drinking purposes. A milky or curdy-looking precipitate will also indicate that the water is hard. If the precipitate is excessive, it masks, to a certain extent, the colour indicative of the test, in which case it is advisable to take a fresh sample in another test-tube, add a few drops of a strong solution of caustic potash, and after the precipitate which is thus formed subsides, add the Nessler re-agent.

(2.) *Nitrites.*—Fill an average-sized test-glass about three-parts full of the water to be examined, then add 5 minims of pure sulphuric acid and 5 minims of a solution of potassium iodide (5 grs. to 1 oz. distilled water), and afterwards pour in a small quantity of freshly-prepared starch solution. This solution is readily prepared by boiling a small quantity of starch powder in a vessel containing distilled water. A blue tint indicates nitrites, and should the colour be at all deep the water is scarcely fit to drink. As iodide of potassium sometimes contains iodate, it is always advisable to make a comparative experiment either with distilled water or with a water which is known not to contain nitrites. Instead of the sulphuric acid, acetic acid may be used, and the starch paste, potassium iodide, and acid, may be mixed before adding the solution to the water.

(3.) *Nitrates.*—The readiest method of testing for nitrates is that known as Horsley's test, of which the following modification has been proposed by Dr. Bond of Gloucester:—Put 20 minims of pure sulphuric acid into a very small test-tube, then add 10 minims of the water to be examined, and afterwards drop in carefully 1 drop of a solution of pyro-gallic acid (10 grs. to 1 oz. distilled water acidulated with 2 drops of sulphuric acid). A pink zone, or sometimes a delicate blue zone changing into a dark amethyst tint, and from that into a brown tint, indicates nitrates. When shaken up, the greater part of this coloration may disappear for a time, but it gradually returns, and after the mixture has stood for a few hours, a permanent tint is developed.

The detection of nitrates in a water derived from a deep well is no evidence of sewage contamination, because, as in the chalk formation, they may be derived from the strata through which the water passes, but in surface or shallow well waters, their presence may fairly be regarded as a suspicious circumstance.

(4.) *Chlorides.*—The amount of chlorine in water can be determined so quickly by a simple volumetric method which will be subsequently described, that those who are provided with the test-solution of nitrate of silver should always adopt this method; but to those who have not this test-solution the following method is recommended:—Acidulate a little of the water in a test-glass with a few drops of dilute nitric acid, and add in excess a solution of nitrate of silver. Four grains per gallon of sodium chloride give a turbidity; 10 grains, a slight precipitate; and 20 grains, a considerable precipitate, soluble in ammonia. A good water should only yield a slight haziness. If there is a distinct precipitate, it shows that the water is derived from a formation rich in salt, such as the new red sandstone, that it is brackish if on the sea-coast, or that it has been contaminated with sewage. In the first two cases there will be a large amount of mineral solids, and therefore, in the case of a soft water, any excess of chlorides would point to sewage contamination. On the other hand, it is important to note that the absence of chlorides from a sample of water renders it very probable that it is free from sewage contamination.

(5.) *Lead and Iron.*—Boil between 3 and 4 oz. of the water acidulated with a few drops of sulphuric acid, and afterwards add sulphuretted hydrogen water. If a brown or blackish coloration is produced, the presence of lead may be inferred. If no colour can be detected, add a little potash or ammonia, and if this produces a blackish precipitate, iron is almost certain to be present. Small traces of iron in a water cannot be considered injurious, but the presence of lead is sufficient to condemn the water as unfit for use.

(6.) *Organic Matter.*—Although the permanganate of potash test has of late years fallen into disfavour with many analysts on account of its indefinitiveness, I am still of opinion that it may be employed with considerable advantage in the qualitative examination of surface well waters, and particularly in localities where salts of iron are not usually found. The following is a convenient method of applying the test:—Fill a tall colourless glass vessel or test-tube nearly full with the water to be examined, and add as much solution of potassium permanganate (2 grs. to 4 oz. distilled water) as will impart a distinct pink tinge after stirring with a glass rod. Then fill another glass cylinder or test-tube of the same size with distilled water, and add the same quantity of permanganate solution. Place the two glasses side by side on a white sheet of paper or porcelain slab, and note any differences between the two tints which may speedily or subsequently take place. If decoloration takes place rapidly or sets in gradually, it shows that the water contains oxidisable organic matter, iron, nitrites, or sulphuretted hydrogen. The last of these is rarely found, and would be distinguished by the smell, while the presence of iron or nitrites can be ascertained by tests already described. In the absence of these three, any rapid decoloration indicates that the organic matter is of animal origin, whereas slower changes indicate that vegetable matter is present. With these limitations, and with a general knowledge of the geological characteristics of the well waters of a district, the test may be advantageously employed as a confirmatory test, though it cannot always be relied on when it gives negative results.

By a judicious application of some or all of these tests, the medical officer of health can examine several samples of water in a comparatively short space of time; but in order to conduct the examination systematically, he ought to arrange the test tubes or glasses in separate sets and number them according to the samples. These, it is presumed, are all derived from surface or shallow well waters, and the following indications will enable him to decide as to whether the water is fit for use or not, or whether it is of doubtful purity, in which case it should be submitted to a quantitative analysis:—

If a water contains a considerable amount of sediment, and is found when decanted off or filtered to show little or no traces of ammonia, nitrates, or chlorides, it shows that it is fit for use, but the well requires cleaning out; or should the well be a tube well, that it ought to be filtered. If the sediment is flocculent and dirty-looking, it will generally be found that the water is polluted in other respects, and an order should be given that the well should be opened, examined, and cleaned out, and any ascertained source of pollution removed. In towns or villages where there is a public water supply, and the premises are within easy reach of a water-main, there should be no hesitation in requiring the well to be closed; or if the ground is so saturated with filth that it is hopeless to expect that any alterations can ensure subsequent safety, an order to close the well should still be insisted on. But supposing the water is tolerably clear, or quite clear, what are the inferences to be drawn from the qualitative examination? If there is distinct coloration on the addition of the Nessler re-agent, but very little precipitate, and with no distinct indications of either nitrites, nitrates, or chlorides, it shows that the water is a soft water and fit for use, and that the ammonia is either derived from rain water or is probably of vegetable origin. If ammonia, nitrites, and chlorides in excess are all present, the water is polluted and unfit for use. A water with an excess chlorides, and which yields a large flocculent precipita on the addition of the Nessler re-agent, but does n become tinted, and gives no indication of the presence nitrites, nitrates, or organic matter, is a hard water, b otherwise fit for use. Should a water contain nitrat and traces of nitrites, but give no distinct indication ammonia or chlorides, it may be considered fit for u If nitrates and chlorides are both present in any exce the water should be regarded as a very suspicious wat and be submitted to a more careful examination, ev though the Nessler re-agent should produce no disti coloration.

In giving instructions as to what action should taken when a sample of well-water is found to be pollut it is always advisable, when there is no public sup within reach, to recommend that the well should be ope and examined. The pollution may arise from want cleansing, or from leakage from a drain, cesspool, or fa yard, and it will depend upon the special circumstan of the case as to whether cleansing and removal of source of pollution will suffice, or whether the well sho be closed altogether, and a new one sunk in some ot suitable place where there is no risk of pollution. I evident therefore that detailed information with regard the situation and surroundings of a polluted well i very material service in advising as to what partic steps should be taken; but, so far as the water itself concerned, the medical officer of health need only rep that it is contaminated and unfit for use. Should recommendations, when notified in the regular way by sanitary inspector, not be complied with, it may beco necessary to submit the water in question to a quanti tive analysis, in order to obtain a magistrate's order cleanse, repair, or close the well, as the case may be.

2. *Quantitative Analysis.*

With the exception of proposed new public supplies, which should in all cases be submitted to a very minute analysis, the only points which require determination in an ordinary quantitative analysis are the total solids, the hardness, the chlorides, and the organic matter as represented by the free and albuminoid ammonia.

(1.) *Total Solids.*—The amount of total solids is ascertained by evaporating a known portion of the water to be examined to dryness. Into a platinum dish which has been carefully cleaned, dried, and weighed, pour 70 cubic centimetres of the sample of water; place the dish in the water or steam-bath, and evaporate to dryness, then wipe the dish externally, and weigh. The difference between the two weighings gives the weight of the residue yielded by 70 cubic centimetres of water. Seventy c. c. are taken, because each milligramme of residue counts for one grain of total residue in a gallon of water, inasmuch as a gallon of water weighs 70,000 grains, and 70 c. c. weigh 70,000 milligrammes.

If the operator has a very delicate balance, and has had some experience in chemical manipulation, 25 c. c. of the water to be examined will usually be found sufficient, but in that case the result in milligrammes must be multiplied by 2·8 (4 × ·7) in order to obtain the total amount of residue in grains per gallon. Thus, to take the following example:—

Weight of dish . . .	24·286	grammes.
,, dish and residue .	24·295	,,
Therefore weight of residue =	·009	,,

But ·009 grammes are 9 milligrammes, and multiplying this number by 2·8 gives 25·2 grains as the amount of solid residue in a gallon of the water examined. If 100

c. c. are taken, the multiple will of course be ·7. The times occupied in the evaporation average about two hours for the 100 c. c., an hour and a quarter for the 70 c. c., and about half an hour when only 25 c. c. are evaporated. In drying the residue, the dish should be put into a hot-air bath, then allowed to cool, and weighed promptly afterwards to avoid deliquescence of the salts.

A very cheap and efficient steam-bath can be made from a pint oil-can by fitting it with a cork which is perforated to admit the stem of an ordinary glass funnel. The can is partly filled with water, and fixed on a retort stand, and the platinum dish is placed in the mouth of the funnel with a piece of folded paper between to permit the escape of the steam.

The total solid residue consists for the most part of mineral matter, and in many waters this is composed chiefly of carbonate of lime. It is difficult to fix the maximum amount of permissible solid residue in drinking water. In public supplies it certainly ought not, if possible, to exceed 30 grains per gallon, but many usable well waters are found to contain double this amount.

The following are examples of the amount of solids in different waters:—

	Grains per Gallon.
Loch Katrine	2·30
Bala Lake	3·18
London Thames Companies	21·66
Rochdale Spring	25·93
Norwich Artesian well	26·70

If a complete quantitative analysis of the saline constituents is required, a much larger quantity of water must be evaporated, but the presence and amount of the more important constituents may be approximately determined as follows:—

a. (*Lime.*)—Pour a little of the water into a test-glass, and add a solution of ammonium oxalate. Six grains of lime per gallon will yield a slight turbidity; 16 grains a distinct precipitate; and 30 grains a large precipitate, soluble in nitric acid.

b. (*Magnesia.*)—In a good water there should only be a slight haziness, or none at all, on the addition of ammonia.

c. (*Sulphates.*)—Acidulate with a few drops of hydrochloric acid and a solution of barium nitrate. A good water should not give more than a slight haziness.

It is seldom, however, that these subsidiary tests are equired. A more important indication is obtained by ncinerating the residue over a flame, when, if blackening occurs, the presence of organic impurities may be inferred, and should a bad smell be given off at the same time, it is almost certain to be derived from impurities of animal origin.

(2.) *Hardness.*—It has already been pointed out that a water is hard or soft according to the amount of solid residue which it contains. Thus a water which contains only three to four grains of residue, such as the Loch Katrine water, is an exceedingly soft water; a water containing eight to ten grains is a moderately soft water; while those which contain twenty grains and upwards are hard waters. For purely sanitary purposes, therefore, the determination of the hardness is seldom required if the total solid residue has been ascertained. The hardness of a water is due to the presence of earthy salts, generally carbonate of lime and sulphate of lime and magnesia. The former is deposited on boiling, and is represented by what is called the removable hardness, while the latter, inasmuch as it is not affected by boiling, is called the permanent hardness. The *rationale* of the process, as first explained by the late Professor Clark, will be understood when it is remembered that if an alkaline oleate, such as soap, is mixed with pure water, a lather is formed almost immediately; but if salts of lime, magnesia, baryta, iron, or alumina are present, oleates of these bases are formed, and no lather is given until the earthy bases are thrown down. As the soap will combine in equivalent proportions with these bases, it is only necessary to make the solution of soap of known strength by standardising it with a known quantity, say of chloride of calcium, to be able to determine the amount of lime or its equivalent of other salts in the water—so much soap required before a lather is produced represents so many degrees of hardness. The standard solutions are prepared and determined according to the following method, proposed by Messrs. Wanklyn and Chapman:—Make a solution of pure calcium chloride of 1·110 grammes to the litre of distilled water. Each cubic centimetre of this solution contains an amount of calcium chloride equal to one milligramme of carbonate of lime. The standard soap test is made by pounding together two parts of lead plaister with one of carbonate of potash, exhausting repeatedly with alcohol at 90 per cent, and using about thirty times as much alcohol as lead plaister. This solution is allowed to stand for some time, and is then filtered, and afterwards diluted with its own volume of water. In order to standardise it 10 c. c. are taken and put into a bottle with 70 c. c. of pure water; the chloride of calcium solution is now added until frothing stops, care being taken to shake properly; and from this trial experiment it is easy to calculate how much dilution of the soap solution is requisite in order to make 17 c. c. of the soap-test use up 16 c. c. of the chloride of calcium solution. The dilution should be made with alcohol of 50 per cent, and the soap-test carefully verified after it has been made up. This is done by adding 16 c. c. of the standard solution of calcium chloride to 54 c. c. of distilled water, thus making a solution of 70 c. c. which should exactly be neutralised by 17 c. c. of the standard soap-test.

A much easier method of making the soap-test, and one which gives fairly accurate results, is to dissolve ten grammes of green Castile soap in a litre of weak alcohol of about 35 per cent. One cubic centimetre of this solution also precipitates one milligramme of carbonate of lime. Either solution, therefore, may be used, and the mode of employing the test is as follows:—

Into a clear glass-stoppered bottle, capable of holding about 250 c. c., put 70 c. c. of the water. Add slowly from a burette the standard soap solution, and shake well until a persistent lather is formed, noting accurately the amount of solution used. Each c. c. of the solution consumed indicates one grain of carbonate of lime or its equivalent in a gallon of water. If, after adding 17 c. c. of the solution, no lather is formed, add 70 c. c. of distilled water and mix, and continue the addition of the soap solution. Should no lather be formed until other 17 c. c. are consumed, other 70 c. c. of distilled water must be added, but in making the calculation for hardness, 1 must be deducted from the number of c. c. of soap solution used for each 70 c. c. of water which have been added, and this deduction is necessary because 70 c. c. of distilled water would themselves neutralise about 1 c. c. of soap-test. Suppose, for example, that 18 c. c. of soap-solution have been required, then 1 must be deducted from the 70 c. c. of distilled water which were added, and the hardness of the sample in question is put down as 17 degrees. In other words, the total soap-destroying power of the water is equivalent to 17 grains of carbonate of lime per gallon. The permanent hardness is obtained by boiling 70 c. c. of the water for about an hour, and making up the loss by evaporation with distilled water. During boiling, the bi-carbonate of lime is decomposed and the carbonate deposited, and thus the water becomes softer. After allowing to cool and filtering, the permanent hardness is determined in the same way as the total hardness, and the difference between these two, as already stated, is the removable hardness

According to Wanklyn's method, the degrees of hardness represent "the potential carbonate of lime," and in translating them into Clark's degrees, it is necessary to deduct 1. Thus, in the above example, the degrees of hardness, according to Clark's standard, would be 16°.

Altogether the importance of this test has been greatly over-estimated, and it is seldom that the medical officer of health will deem it necessary to employ it.

(3.) *Chlorides.*—The estimation of chlorine as chlorides in water can be readily determined volumetrically by means of chromate of potash, and a standard solution of nitrate of silver. This solution is prepared by dissolving 4·79 grammes of dry nitrate of silver in a litre of distilled water. As chromate of silver is soluble in acids, it is necessary that the nitrate of silver used should be neutral. Each c. c. of this solution precipitates 1 milligramme of chlorine. 70 c. c. of the water to be examined are put into a beaker or evaporating dish, and a small crystal of pure chromate of potash, or a few drops of a strong solution of this salt added, sufficient in either case to produce a distinct yellow tint. The standard solution is then dropped carefully in from a graduated pipette or burette, and directly the first faint tinge of red is discernible and remains permanent on stirring, the whole of the chlorine is precipitated, and chromate of silver, which is a dark red, is formed. The number of c. c. of the solution used before this red tinge is obtained represents the number of grains of chlorine per gallon of water. If, for example, 3·5 c. c. of the solution have been required, the water contains 3·5 grains of chlorine per gallon.

The following are examples of the amount of chlorine in different waters :—

	Grs. per Gallon.
Thames at Kew	·847
Thames at London Bridge . . .	4·452
Bala Lake	·706
Polluted well at Rugby . . .	7·5

The indications afforded by the chlorine test have previously been dwelt upon in the remarks on the qualitative examination of water, and they need not therefore be further referred to here.

(4.) *Ammonia and Organic matter.*—Of the two rival methods of estimating the organic matter in water—namely, that of Frankland and Armstrong, and that devised by Wanklyn, Chapman, and Smith—there is a general concurrence of opinion that the latter is especially suited for the medical officer of health, because it is easy of application, and yields sufficiently accurate results for ordinary hygienic purposes. Frankland's process of estimating the organic carbon and nitrogen is a method of no small difficulty, and in the hands of any but an experienced chemist the risk of experimental error is very considerable. What is known as the *Ammonia process*, therefore, will be the process described here. For a full description of this process the reader is referred to Mr. Wanklyn's excellent text-book on water analysis, from which the following remarks are for the most part collated. The *rationale* of the process depends upon the fact that vague and indefinite nitrogenous bodies can be converted nto a definite compound, namely ammonia, and that in his way they can be estimated and expressed as ammonia. Owing to the excessive minuteness of the quantities of nitrogenous compounds which distinguish between a good and a bad water, it is convenient to adopt a much finer cale of measurement than is requisite for the saline constituents; and the amount of ammonia is accordingly expressed by milligrammes per litre, or so many parts in a million. Indeed, the delicacy of the process is such that there is no difficulty in being able to discover one part of recent sewage in 2000 parts of drinking water. The re-agents which are employed are the Nessler test, a standard solution of ammonia, a saturated solution of carbonate of soda, and a solution of potassium permanganate and caustic potash.

a. Nessler Test.—Dissolve, by heating, 35 grammes of iodide of potassium and 13 grammes of corrosive sublimate in about half a litre of distilled water, and afterwards add gradually a cold saturated solution of corrosive sublimate, and keep stirring until the red colour produced begins to be permanent. Then add 160 grammes of caustic potash dissolved in about 200 c. c. of distilled water, and dilute with sufficient water to bring the whole up to a litre. To render the test sensitive, add about 20 more c. c. of the saturated solution of corrosive sublimate, and allow it to stand in a stoppered bottle until the precipitate has subsided. The clear liquid may now be decanted and kept in a tightly stoppered stock bottle ready for use.

b. Standard Solution of Ammonia.—Dissolve 3.15 grammes of crystallised sal ammoniac or ammonium chloride in one litre of distilled water. Every cubic centimetre of this solution contains one milligramme of ammonia. This is termed the strong solution, and is the most convenient to keep. To prepare the dilute solution, put 5 c. c. of the strong solution into a half-litre flask, and fill up with distilled water. This is the standard solution of ammonia, and contains 0·01 milligramme of ammonia in one cubic centimetre of water.

c. The Saturated Solution of Carbonate of Soda may be prepared by boiling an excess of the common carbonate in distilled water. About 10 c. c. of this solution is the proper quantity to use, or instead of the solution, about one gramme of the dry carbonate of soda, which has just been ignited, may be employed. The carbonate of soda is used in order that the free ammonia may be more easily dispelled on distillation.

d. The Permanganate of Potash and Caustic Potash Solution is prepared as follows:—Dissolve 8 grammes of crystallised permanganate of potash, and 200 grammes of solid caustic potash in one litre of distilled water. Boil the solution for some time to free it from all traces of ammonia, and afterwards replace the water lost by evaporation by adding sufficient distilled water to make up the litre.

The distilled water which is used to make up the various solutions may be obtained of sufficient purity from any common drinking water, if care is taken to reject the first portions of distillate, and the distillation is not pushed too far. It should always be carefully tested before being used, and so chemically pure that in 100 c. c. there ought not to be 0·005 milligramme of ammonia.

The following is a list of the apparatus required for the process (see also Appendix):—A stoppered retort capable of holding at least one litre; a Liebig's condenser; a good-sized Bunsen's lamp or burner; a retort-holder; about half a dozen Nessler glasses made of white glass, and with a mark at 50 c. c.; a half-litre flask; a graduated burette marked into c. c., to measure off the standard solution of ammonia; and a pipette marked to hold 2 c. c. It need hardly be said that the greatest care must be taken to have the whole of the apparatus thoroughly clean before it is used. Glass vessels should first be washed out with a little strong hydrochloric or sulphuric acid, and afterwards with pure water.

The analysis itself is thus performed:—After mounting the retort on the holder, and properly connecting it with the Liebig's condenser, half a litre of the water to be examined is poured into it, and 10 c. c. of the solution of carbonate of soda added. The Bunsen lamp is now lighted, the retort thrust well down into the flame, and 50 c. c. are distilled over into a Nessler glass, and *Nesslerised.* Then distil over 150 c. c. and throw this distillate away. This amount is thrown away because it has been found that the first distillate contains exactly three-fourths of the free ammonia present in the water, and it is therefore a waste of labour to Nesslerise the whole of the four 50 c. c. distilled over. There are now 300 c. c. left in the retort, and in order to liberate the "albuminoid ammonia," 50 c. c. of the permanganate of potash and caustic potash solution are poured into the retort by means of a wide funnel. To prevent bumping, which is very liable to occur with a bad water, the retort should be gently shaken, so as to give the mixture a wavy motion. The distillation is then continued, and three separate distillates, each of 50 c. c., taken and Nesslerised.

What is called Nesslerising is the process of ascertaining the strength of a dilute solution of ammonia by means of the Nessler re-agent, and is indeed one of the most beautiful examples of colorimetric analysis. Let the first distillate of 50 c. c. be taken as an illustration. To this distillate, which is contained in one of the Nessler glasses, 2 c. c. of the Nessler re-agent are added by means of the 2 c. c. pipette, which also serves as a convenient stirrer. If, after stirring and waiting about a couple of minutes, the liquid assumes a rich deep brown, it contains much ammonia; if even a distinct brown tint is developed, it contains a considerable quantity of ammonia; but if it remain colourless, it does not contain so much as ·005 milligramme. When only a light-yellowish tint is produced, the amount of ammonia present is comparatively small. In any case, however, the exact amount s determined by comparing with a known solution of mmonia. The depth of tint in the distillate is imitated y mixing, in a Nessler glass, more or less of the dilute tandard of ammonia contained in the burette with dislled water, and filling up to 50 c. c., and then adding 2 c. of the Nessler re-agent. If, after stirring and waiting wo or three minutes, the tint developed in the artificially repared solution is too dark or too light, it is necessary make another artificial solution of less or greater rength, as the case may be. With a little practice it easy to approximate very closely to the exact amount f the standard solution of ammonia which will be reuired to produce a tint on the addition of 2 c. c. of the Nessler re-agent, which will harmonise completely with he tint of the distillate. In order to be able to compare he tints accurately, the Nessler glasses should be placed n a white porcelain slab or sheet of white paper. The umber of cubic centimetres of the standard solution of mmonia, which on the addition of the Nessler re-agent were required to reproduce the exact tint given by the distillate, are noted, and the amount of "free ammonia" contained in the sample of water can then be readily calculated.

The other three distillates which contain the albuminoid ammonia are Nesslerised in the same way, and the amount of the standard solution of ammonia, which was required to imitate the tint in each case, is also noted. These several amounts added together represent the total "albuminoid ammonia" contained in half a litre of the water. It has already been pointed out that the first 50 c. c. which were distilled over contain three-fourths of the whole of the "free ammonia," and that therefore the next 150 c. c. distilled over may be thrown away. It was formerly the practice of Mr. Wanklyn to Nesslerise the whole four 50 c. c. to obtain the total of the free ammonia, but the amount contained in the first distillate was found to bear such a constant ratio to the amount contained in the other three distillates, namely, as 3 to 1, that it becomes a needless expenditure of labour to Nesslerise them. The rule, therefore, is to add one-third to the amount of ammonia found in the first distillate, in order to obtain the whole of the free ammonia.

Remembering now that each cubic centimetre of the standard solution contains ·01 milligramme of ammonia, the calculation in any given case becomes very simple. For example, suppose the amount of dilute standard solution of ammonia required to match the tint in each case to be as follows:—

Free ammonia distillate		2 c. c.
Albuminoid ammonia	1st distillate	5 ,,
	2d ,,	2·5 ,,
	3d ,,	·5 ,,

then we arrive at the following amounts:—

		Milligrammes.
Free ammonia = $\cdot 02 + \frac{\cdot 02}{3}$	=	·027
Albuminoid ammonia	1st distillate	·05
	2d ,,	·025
	3d ,,	·005
	Total albuminoid ammonia	·08

But inasmuch as half a litre of water was taken for analysis, these results must be multiplied by 2 in order to arrive at the amounts per litre, or per million parts. In the above example, therefore, the results would be stated as follows:—

		Parts in a million, or milligrammes per litre.
Free ammonia	=	·054
Albuminoid ammonia	=	·16

In this process of water analysis it will be observed from the above description that ammonia is to be looked for at *two stages*; firstly, in distilling off with the carbonate of lution; and secondly, on distilling off with the permanganate solution. The first portion of the a is called the "free ammonia," because it is ob- rom the decomposition of those organic impuri- ater which are of simple constitution, such as the ss, as well as the ammonia which may be present nia. The second portions of ammonia are named noid ammonia," because the ammonia which is ff is derived from the oxidation of those more nitrogenous impurities which are closely allied to .

following are examples of pure, indifferent, and nples of water, as determined by the ammonia —

	Free Ammonia, parts per 1,000,000.	Albuminoid Ammonia, parts per 1,000,000.	Quality.	Name of Authority.
rine . .	·004	·08	Good	Wanklyn
om Kent Com- mains . .	·01	·02	,,	,,
h Water Sup- linton, 1867 .	·14	·08	Indifferent	,,
Helen's pump, 1 . . .	3·75	·18	Bad	,,

h regard to the inferences which may be deduced ng the quality of a water as indicated by this of examination, Mr. Wanklyn has laid down the g rules in the third edition of his work on water :—"If a water yield ·00 parts of albuminoid a per million, it may be passed as organically spite of much free ammonia and chlorides; and d, the albuminoid ammonia amount to ·02, or to n ·05 parts per million, the water belongs to the very pure water. When the albuminoid am- mounts to ·05, then the proportion of free ammonia becomes an element in the calculation; and I should be inclined to regard with some suspicion a water yielding a considerable quantity of free ammonia, along with ·05 parts of albuminoid ammonia per million. Free ammonia, however, being absent or very small, a water should not be condemned unless the albuminoid ammonia reaches something like ·10 per million. Albuminoid ammonia above ·10 per million begins to be a very suspicious sign; and over ·15 ought to condemn a water absolutely." There is no doubt, however, that there are many surface well-waters in country districts containing even more than ·15 parts per million of albuminoid ammonia, and to which no bad effects can be traced, but in these cases it is probable that the ammonia is chiefly derived from vegetable matter. If the quantity of chlorine found in a water is exceedingly small, any excess of albuminoid ammonia would indicate that the nitrogenous matter present is of vegetable and not of animal origin, and therefore comparatively innocuous. At the same time it should be remembered that there might be the same absence of chlorine if the water becomes polluted from the presence of the body of a dead animal in a well or cistern.

In conducting a water analysis, it is expedient, if the amount of solids is to be taken, to commence the evaporation for the solids first, then to commence distilling for the ammonia, and while the evaporation and distillation are going on, to determine the amount of chlorides, and the degree of hardness, if that be considered necessary. It is always advisable to keep a detailed record of the results of every analysis in a book set apart for that purpose. The form of report or certificate will of course vary according to the number of data, and the mode of analysis, but the following hints will indicate generally how it should be drawn up:—

Date of reception of sample, size and description of bottle or ttles, how stoppered or sealed, and how labelled.

ysical Examination.

Appearance .	(Clear, or slightly turbid, etc.)
Taste . .	(Tasteless, or unpleasant, etc.)
Odour . .	(Odourless, fœtid, etc.)
Deposit . .	(Slight or large, dirty-looking, flocculent, etc.)

icroscopic Examination.

(Sandy particles, vegetable matters, animal matters, vibriones, etc.)

emical Examination.

Qualitative results :—

Nitrites . .	(None—traces—large amount.)
Nitrates . .	(None—slight traces, etc.)
Sulphates . .	(None—slight traces, etc.)
Metals . .	(None—traces of lead, etc.)

Quantitative results :—

Total solids .	(In grs. per gallon.)
Chlorides . .	(In grs. per gallon.)
Hardness, total .	(In degrees.)
„ permanent	(In degrees.)
Free ammonia .	(Parts per million.)
Albuminoid ammonia	(Parts per million.)

Remarks as to whether the water is soft or hard, of good quality nd fit for use, or whether it is polluted and unfit for use.

Date of analysis,—signature, etc.

Exclusive of the microscopic examination, which is ldom undertaken or required, a water analysis giving e above data may be completed in about an hour, rovided of course that the operator is fairly expert at s work and has all his test and standard solutions prered beforehand. The busy medical officer of health ay obtain most of these solutions, as well as distilled ater, from chemists, but he should always make blank periments to test their purity and quality.

Although I have thus far endeavoured to describe early and concisely the various steps of an ordinary water analysis, I nevertheless consider it very essential that every one who has to undertake this kind of work should receive some lessons in the laboratory of a competent analyst. If he is precluded from doing this, he may teach himself, provided that he has a fair knowledge of elementary and practical chemistry, but in this case he ought to experiment with samples obtained from a public supply, and compare his results with those of recorded analyses of that supply.

As already stated, any proposed new public supply should be submitted to a full quantitative analysis of its saline and other constituents, and for this purpose samples should be sent to a professed analyst. It should not only be usable, but the best which can be procured within the limits of reasonable expenditure. All waters subjected to filtration should be examined from time to time, to ascertain that the filtering process is carried on efficiently. Any water which gives indications of having become contaminated with animal or other impurities, and which has hitherto been good and wholesome, should be entirely disused until the source of contamination has been discovered and removed.

A list of tests, etc., is given in the Appendix.

CHAPTER VIII.

IMPURE WATER, AND ITS EFFECTS ON PUBLIC HEALTH.

ALTHOUGH impure water has long been recognised as one of the most potent causes of disease, it is only of recent years that minute investigation has succeeded in demonstrating the terrible mortality which it inflicts on all classes of the community. It is true that chemical analysis often fails in detecting the special impurities on which the development of certain diseases depends; it is also true that, even when impurities are detected, it is extremely difficult to estimate their exact etiological value; nevertheless, the broad fact remains, and it is founded on evidence of the most conclusive kind, that a vast number of cases of disease are attributable to the use of impure water, and there are good grounds for believing that, as investigations become more frequent and precise, a continually increasing class of such cases will be discovered. It must also be remembered that the effects of impure water, like the effects of impure air, may engender a general impairment of the health, without giving rise to well-pronounced disease.

Water impurities and their effects may be conveniently considered as follows:—Firstly, water rendered impure by an excess of mineral substances; secondly, water rendered impure by the presence of vegetable matter; thirdly, water rendered impure by animal organic matter.

SECTION I.—WATER RENDERED IMPURE BY AN EXCESS OF MINERAL SUBSTANCES.

As all potable waters contain a certain amount of mineral matters, it is extremely difficult to decide the quantities of these ingredients which may be present, either singly or collectively, without producing bad effects. This much, however, may be said, that waters of a moderate amount of hardness, provided that the hardness depends chiefly on the presence of calcium carbonate, are not found to be detrimental to health. A water of 8 or 10 degrees of temporary hardness, equivalent to about as many grains per gallon of total mineral solids, may be pronounced good and wholesome, while one of as many degrees of permanent hardness would prove injurious to many persons. With regard to the wholesomeness of Thames water, with a hardness averaging 15 degrees before boiling and 5 degrees after, the evidence given before the Royal Commission on Water Supply, 1869, is somewhat conflicting; for while Dr. Letheby considered a moderately hard water, such as the Thames water, best suited for drinking purposes and the supply of cities, Dr. Parkes maintained that the amount of hardness should not exceed 10 or 12 degrees, if possible. Mr. Simon and Dr. Lyon Playfair, on the other hand, although they did not condemn the London water on account of its hardness, both expressed themselves in favour of a softer water for purposes of health. The inference that may be drawn from this and other evidence would therefore appear to be this, that the total hardness of a good water ought not to exceed 15 degrees, nor the permanent hardness 5 ; or, in other words, that even in a moderately hard water, calcium carbonate must always greatly exceed the magnesium and calcium sulphates and sodium chloride.

The symptoms referable to an excess of hardness, sing from the presence of earthy salts, are mainly of dyspeptic nature. According to Dr. Sutherland, the e of the hard waters derived from the red sandstone ks underlying Liverpool, produced in many cases con- pation and visceral obstruction, and, an excess of calcium d magnesium sulphates (7 to 10 grains per gallon) has n known to produce diarrhœa.

The special disease, however, which, more than any er, seems intimately connected with the mineral in- dients of water, is goïtre. In Nottingham, where the ease prevails to a certain extent, the common people ribute it to the hardness of the water; and in other ts of England, such as Yorkshire, Derbyshire, Hamp- re, and Sussex, it is found to prevail only in those dis- ts where the magnesian limestone formation abounds. cording to Dr. Coindet of Geneva, the disease is edily produced in persons drinking the hard pump ter in the lower streets of that town, while in other ts of Switzerland the use of spring water has been lowed by the production or augmentation of the ease in a few days. In India, again, the researches, re especially of Dr. M'Clellan, show very conclusively t it is found to prevail only where the magnesian estone formation prevails. Whether lime and magnesian ts, or ferrum sulphide, as has been suggested by M. int-Lager, be the active agents in producing the dis- e, has not yet been rendered quite clear; but it appears tain that goïtre is originated by water-impurities, d that these are of an inorganic and not organic nature. cording to Johnston, the prisoners in Durham jail re at one time affected with swellings of the neck, d on analysis the water-supply was found to contain 7 grains of lime and magnesian salts per gallon. The wellings disappeared when a purer water was obtained. –(*Parkes.*)

With regard to this subject, Dr. Brushfield of Brookwood, Woking, has directed my attention to the prevalence of goïtre at Pirbright, a village near Brookwood, especially amongst the inhabitants who live along the course of a certain brook. Even the clergyman's wife contracted the disease after she had been resident there for a short period. But instead of magnesian limestone, the geological formation throughout the district consists of Bagshot sands overlying the London clay. Goïtre has become much less common since sanitary matters have been better attended to.

The effects of minute traces of metallic compounds in drinking water are as yet comparatively unknown. It is quite possible that the sanitary condition of a district may in some measure depend on impurities of this description, and, as Mr. Wanklyn suggests, that the salutary effect of "change of air" may be partly due to change in the minute metallic impurity in the water of the parts of the country which are visited.

Of the metallic ingredients, the effects of iron and lead have been the most fully ascertained. It would appear that iron, if present in quantities large enough to impart a chalybeate taste to the water, often produces headache, slight dyspepsia, and general *mal-aise,* while impregnation with lead from leaden cisterns or pipes has frequently been followed by symptoms of lead-poisoning. In the case of the ex-royal family of France, many of whom suffered when at Claremont from this species of water contamination, the amount did not exceed one grain per gallon; indeed, from cases which have since occurred, it seems probable that the habitual use of water containing from one-tenth to one-twentieth of a grain per gallon may be attended with danger. In his investigations with regard to the Devonshire colic, which formerly prevailed to a great extent, Sir George Baker found that ghteen bottles of cider which he examined contained ½ grains of lead, or a quarter of a grain to each bottle. ıe impregnation arose from lead being employed in the nstruction of the cider troughs. With regard to the inor effects of lead-poisoning, there are good grounds : believing that many obscure forms of disease, partak- ; more particularly of the nature of dyspepsia and lic, are due to this cause.

Arsenic, copper, or mercury, are only found in the inking waters of this country in injurious quantities ıen streams are polluted by the washings from mines chemical works.

SECTION II.—WATER RENDERED IMPURE BY VEGETABLE MATTER.

Vegetable matter may be present in water either in pension or in solution. In peaty water, which is acterised by its brownish tint, the dissolved impurities etimes do not exceed two grains per gallon. In the nce of a purer supply, a water of this description ıot be pronounced objectionable, provided that it is stored in leaden cisterns, and that the supply is con- t. If stored in open-air ponds or reservoirs, it is oved by oxidation and light; and it is further im- ed by filtration through gravel and sand.

Water containing a considerable amount of vegetable er, partly in suspension and partly in solution, is ledly unwholesome. It has been known to produce nt outbreaks of diarrhœa, and, since the days of pocrates downwards, it has been popularly acknow- ed to be productive of ague and other malarious ıents. In this country there are several instances record, that ague has been much lessened in small mmunities by using well instead of surface water; and there is strong presumptive evidence that, apart from the influences attaching to improved drainage, the great decline of this disease throughout many parts of England where it formerly prevailed, is in some measure due to the use of purer water.—(*Parkes.*)

SECTION III.—WATER RENDERED IMPURE BY ANIMAL ORGANIC MATTER.

From a sanitary point of view, this is by far the most important class of water impurities. The presence of putrescent animal matter, whether it has percolated through the soil from cesspools or other filth-accumulations into wells, or whether it has been discharged from open sewers into streams and rivers, converts drinking water into a dangerous poison, fraught with disease and death. It is true that to a certain extent the process of filtration through a porous soil tends to render less hurtful the sewage which dribbles into a well, but after a time this purifying power is lost, the soil becomes sodden, and the sewage enters unchanged. It is also true that, given a sufficiently large stream, a sufficient length of course, and a sufficient length of time, the greater portion of the sewage discharged into a river will become converted into harmless products by oxidation. Yet neither process can be trusted, however complete it may appear to be. There is always danger lurking in a water which is known to be contaminated with animal matter, and more especially when such matter is partly composed of the evacuations of patients suffering from certain specific diseases, such as cholera or enteric fever. The germs of disease, which may be communicated in this way, have a tenacity of life or chemico-physical power altogether beyond our knowledge.

Leaving out of consideration the question whether animal organic matter in suspension or in solution is the nore injurious to health, it would appear that it is the uality rather than the quantity which determines the anger. As already stated, a trace of fæcal matter, espeially when undergoing active chemical change, may render public well poisonous, while a stream of sewer-gas may ontaminate the contents of a cistern, and be the means f prostrating a whole household.

The principal diseases which have been proved to be roduced by this class of water impurities are, cholera, nteric fever, dysentery, and diarrhœa.

1. *Cholera.*—Although much had been previously ritten with regard to the etiology and spread of cholera, was not generally surmised that the disease could be opagated by a polluted water-supply until the late Dr. now published the results of his researches in 1849. At st Dr. Snow's views were rejected by some, or quesned by others; but in 1854 there occurred a violent tbreak of cholera in the parish of St. James, Westinster, the causes of which were inquired into by a comittee of medical men, whose report fully substantiated r. Snow's conclusions. Between the 31st August and e 8th September of that year, as many as 486 fatal ses occurred within an area bounded by a circle whose dius scarcely exceeded 200 yards. On inquiring into e local peculiarities of the epidemic, Dr. Snow found at the sufferers had been in the habit of drinking the ater supplied by a pump-well in Broad Street, which d a great reputation for freshness and sweetness. An alysis of the water proved that it was highly charged ith animal impurities, and, at Dr. Snow's earnest solicitan, the handle of the pump was removed by order of the stry on September 8th, to prevent further use of the ater. After this the disease gradually subsided, and timately disappeared. It was made manifest, by a bsequent examination, that the sewage of a neighbour-

ing house had leaked into the well, and it was further ascertained that the evacuations of a patient residing in the house, and who was suffering from diarrhœa, or actual cholera, must have mingled with the sewage immediately before the occurrence of the general outbreak. No evidence could well be more convincing that, in this instance at least, the choleraic poison had been conveyed by the drinking water.

Amongst other remarkable outbreaks which go to prove that this mode of cholera propagation is not at all uncommon, may be mentioned the following:—In the autumn of 1865, a gentleman and his wife, from the village of Theydon-Bois in Essex, had been lodging at Weymouth for two or three weeks, and returned home towards the end of September. On their way home they passed through Dorchester, where the gentleman was seized with diarrhœa, vomiting, and cramps, which continued more or less during the next day, and the day following, when they reached Theydon-Bois. During the journey the wife also began to complain of abdominal pain, which was followed by diarrhœa and eventually by cholera, from which she died. A few days after their return, the disease rapidly attacked other members of the household, so that, "within a fortnight, in that one little circle, eleven persons had been seized with cholera—mother, father, grandmother, two daughters, son, doctor, serving-lad, servant-maid, labourer, and country-woman; and of these eleven only three survived—the son, a daughter, and the serving-lad. Later, in the country-woman's family, there was another fatal case. It cannot well be doubted," continues Mr. Simon, "but that the exciting cause of this succession of events was, in some way or other, the return of the parents from Weymouth, of the father with the remains of choleraic diarrhœa *still on him*, of the mother with apparently the beginnings of e same complaint. But this is only part of the case, d the remainder teaches an impressive lesson. All inking water of the house came from a well beneath the or of the scullery, and into that well there was habitual akage from the water-closet."—(*Eighth Report of the edical Officer of the Privy Council.*)

In addition to Mr. Simon's report on the cholera idemics of London in 1848-49 and 1853-54, in which ere is sufficient evidence to show that the prevalency of e disease in certain districts was almost entirely deterined by the degree of impurity of the water-supply, the nclusions, more especially of Dr. Farr and Mr. Radcliffe, ith regard to the localisation and distribution of the idemic of 1866, are, if possible, more confirmatory still. us, Dr. Farr, in his evidence before the Royal Commison on Water Supply in 1869, states that "in all the stricts supplied by the Grand Junction, the West iddlesex, and the Chelsea Water-works Companies, the ortality was about 3 in 10,000; in those supplied by e Southwark and Lambeth Companies, which were forerly so heavily visited, it was about 6 in 10,000; and those supplied by the New River Company, about 8 in 0,000; while in those supplied by the East London ompany, from the Old Ford Reservoirs, it was 79 in 0,000." In effect, the area of explosion was found to e limited to the district supplied by the East London Vater Company, and not only so, but Mr. Radcliffe's vestigations proved that the water delivered from the ld Ford covered reservoirs had been polluted with water rom the filthy uncovered reservoirs, and that these latter ad, in all probability, been contaminated with soakage rom the River Lea, which received the evacuations of the rst two patients who died of epidemic cholera in the astern districts.

With regard to Scotland, the evidence of Dr. Stevenson

Macadam, as to the influence of impure water on the spread of cholera, is also very conclusive. In a report read before the members of the British Association in 1867, he showed very clearly that the ravages of the disease were coincident in time and place with the use of water from impure wells, and that in all cases the abatement of the outbreak followed the introduction of a pure and fresh supply.

Without quoting further evidence, it is sufficient to state that the weighty authority of Dr. Parkes strongly confirms this view of choleraic contagion; and indeed the opinions of Professor von Pettenkofer, though at first sight they appear to be antagonistic to the theory, do in reality support it. For, while he considers that the propagation of cholera is due to a fermentation of the rice-water stools, he also maintains that this ferment can only act, and the contagion be generated, under certain local conditions—namely, when there is a damp porous subsoil to receive the ejecta. Although Pettenkofer believes that the air is the sole channel by which the cholera miasm, thus generated in the soil, is spread, there is no doubt that the bearing of the geological influence amounts only to this,—that where populations are living on a damp open subsoil, with no artificial water-supply, nor any efficient system of drainage, there the drinking water, as well as the local atmosphere, is almost certain to be largely polluted by those fæcal impurities amid which the diarrhœal contagia are peculiarly apt to multiply.—(*Simon.*)

Whether cholera can be produced by animal organic matters not of a specific nature, is still an open question. Very probably the effect of constantly drinking a certain amount of these impurities produces a lowered state of the system and a tendency to diarrhœa, so that, when the cholera poison is abroad in the atmosphere, it finds its *victims* in largest numbers amongst those who partake of in impure water-supply. This much, however, appears certain, that whenever cholera evacuations make their way into the drinking water, we may expect to find the disease burst forth with the greatest virulence and fatality amongst those who use the water, and that indeed the ndemic area will approximate with remarkable closeness o the limits of the district which it supplies.

2. *Enteric or Typhoid Fever.*—The remarks which have just been made with regard to the influence which mpure water exerts on the spread of cholera, apply with till greater force to the etiology of enteric fever. For, although there are still some who do not believe in the communicability of the disease, there is a constantly accumulating amount of evidence, which goes to prove not only that the poison of the fever may be conveyed through the agency of water from the sick to the healthy, but that this is the most common mode of propagation. Sir W. Jenner, than whom no higher authority could well be quoted, in commenting on this point, says,—"The spread of typhoid fever is, if possible, less disputable than the spread of cholera by the same means. Solitary cases, outbreaks confined to single houses, to small villages, and to parts of large towns—cases isolated, it seems, from all sources of fallacy—and epidemics affecting the inhabitants of large though limited localities, have all united to support by their testimony the truth of the opinion that the admixture of a trace of fæcal matter, but especially the bowel excreta of typhoid fever, with the water supplied for drinking purposes, is the most efficient cause of the spread of the disease, and that the diffusion of the disease, in any given locality, is limited, or otherwise, and just in proportion as the dwellers of that locality derive their supply of drinking water from polluted sources."

According to Dr. William Budd it also appears to be highly probable that when the poison is conveyed by water, infection is much more certain than when it is disseminated by the air; and in support of this statement he instances an outbreak which occurred in Cowbridge in Wales, in 1853, where, out of some 90 or 100 persons who went to a ball, fully one-third were shortly afterwards laid up with fever. Although the water was not examined, there was satisfactory reason to believe that it was polluted.

Since that date numerous other local outbreaks have been carefully investigated, and some with so much precision and completeness of detail that they are noticed here rather as examples of the painstaking and systematic way in which such inquiries should be conducted, than as proving this mode of propagation of enteric fever:—

(1.) In the spring of 1867 Dr. Thorne, one of the Health Inspectors of the Privy Council, was ordered to proceed to Winterton in Lincolnshire, to inquire into the causes of the excessive mortality from enteric fever which had prevailed more or less during the previous two years in different parts of the town, but had latterly assumed alarming proportions. The small town numbered about 1800 inhabitants, of whom about nine-tenths consisted of the labouring classes, living for the most part in well-built cottages and earning good wages. Absolute poverty was little known amongst them, intemperance was rare, and only in two instances was there any overcrowding. Moreover, the situation of the town was healthy, inasmuch as it was built on a gentle slope facilitating drainage, and the subsoil was open and porous, consisting of a stratum of oolitic limestone covered by a light marly soil. Yet, with all these advantages, the number of deaths in 1865 amounted to 51, and in 1866 to 44, and of these more than a third had died of enteric fever. At the date of Dr. Thorne's visit 55 cases were under treatment, and already 6 deaths had occurred since the beginning of the year. The cause of all this sickness and mortality is best given in Dr. Thorne's own words:—

"The epidemic prevalence of fever in Winterton is undoubtedly to be ascribed to the disgraceful state of the privies, cesspools, ashpits, and wells. With the exception of about six houses, where water-closets have been constructed, all the cottages are provided with privies, which are generally built of brick, and have an aperture at the side or back, through which they can be cleaned out. This aperture I found open in almost all instances, and the result of this is that the contents of at least half the privies in the town run out into the gardens, soak into the earth, and penetrate in many instances into the wells, besides producing the most offensive odour. In addition to this many of the tenants either throw their refuse and slops, including urine, into the yards outside their doors, or else they improvise a receptacle by digging in the ground close to the aperture in the privy wall. The fæcal matter pours into it, and they thus add to their previous list of nuisances that of an open cesspool. In some instances ashpits have been built, but these are uncovered, and since urine and the bowel discharges of the typhoid patients are thrown into them, in addition to other refuse, they are but little better than open privies. All these sources of fæcal fermentation are situated, as a rule, close to the houses, and in some instances within a few feet of the back doors, and just under the windows. The wells are also in their immediate neighbourhood, and many of the inhabitants informed me that their water was so bad that they had been compelled to discontinue drinking it. In one instance I found the space between two pigstyes entirely occupied by a well 3 feet in diameter. Fever is present in the house to which this well is attached, but since the occupants do not use it, the necessarily contaminated condition of the water cannot be considered to bear upon the disease. Given the existence of typhoid fever in a town, it is hardly possible to conceive of conditions more favourable for its spread than those existing in Winterton."

Then follow details, and amongst them these:—

Behind a group of four cottages there was a small open court common to them all, and in this court a well to supply the drinking water. Within a circuit of 14 feet round the well, Dr. Thorne found a choked-up drain; an ashpit, on which the fever evacuations were thrown; two pigstyes; three privies, nearly filled with night-soil; and an open cesspool, into which one of the privies emptied itself. In three of the cottages where the epidemic had been so rife, the inmates used the water from this well; while those living in the fourth, and who drew their water from a neighbour's well, had always enjoyed good health. On examination the water was found to be of a light brown colour and disagreeable taste, and to yield a considerable deposit after standing for some time, which contained a large quantity of organic matter, infusoria, and other animalculæ.—(*Tenth Report of the Medical Officer of the Privy Council.*)

(2.) In the autumn of the same year (1867) a severe epidemic of enteric fever broke out in Guildford. Dr. Buchanan, who was the Government Inspector on this occasion, found that during the first twenty-eight days o August, 10 cases of the disease had occurred in different parts of the town; when suddenly, within the next thirty-three days, the number arose to about 250. As th epidemic was almost exclusively confined to a part of th town which corresponded with a particular section of th public water-supply, suspicions were aroused that this ha become polluted; and on further investigation it was ascertained that on a particular day about ten days befor the outbreak, the houses in that part of the town had bee *exceptionally* supplied with water from a certain high-standing reservoir which had previously been filled from a new well. This well was sunk through a porous stratum of chalk, and in close proximity to it were various sewers, one of which was afterwards found to be leaking in several places. There was no doubt, therefore, that sewage had oozed through the chalk into the well, and had caused the epidemic. An analysis of a sample of the water was subsequently made by the late Professor Miller, the results of which gave unmistakable evidence of previous sewage contamination. — (*Tenth Report of the Medical Officer of the Privy Council.*)

(3.) The account of the epidemic at Terling in Essex by Dr. Thorne is especially valuable as showing the effect of a sudden rise of the ground-water level in a village situated on a porous subsoil, obtaining its water-supply from shallow wells, and allowing its excrementitious filth to accumulate in badly-constructed privies and manure heaps, or to lie indiscriminately in scattered masses on the surface of the ground. Out of a population of 900, about one-third of the number were attacked with enteric fever within a period of two months, and 41 had died. Some ten days before the outbreak, and after a period of prolonged drought, a sudden great rise in the water-level of the wells was observed to follow a heay fall of rain and snow; in other words, the shallow unprotected wells sunk in the porous gravel had become converted into so many receptacles for the washings of the filth-sodden soil, and hence the epidemic.—(*Tenth Report of the Medical Officer of the Privy Council.*)

(4.) In the beginning of 1873 a severe outbreak of enteric fever occurred in the small town of Sherborne in Dorset, which was investigated by Dr. Blaxall, and which is of extreme interest as having been the first outbreak of the kind which was clearly traced to the entrance of sewer air into the water mains. Although the water supply was intended to be constant, it was ascertained that in December of 1872, and January 1873, the water was frequently shut off at a point near the reservoir, and that during the month of February it was shut off every night. It was observed that when the water was turned off there were certain water-mains up which there was a sudden rush of air immediately the tap was unscrewed, and as many of the mains communicated directly with closet-pans by means of taps, which were sometimes left open, and which in other instances were broken, there were thus numerous inlets for the entrance of air from the closet-pans into the water-mains. Moreover, if a pan happened to become full of excremental filth, there was the probability of excrement as well as sewer air having been sucked into the mains. In January and February there were about 27 cases of fever in the town, but before the end of April the number altogether had increased to 240, out of a population of 6041. After the first week, during which 73 cases occurred, the water supply was again made constant, and the epidemic gradually declined. —(Mr. Simon's *Reports*, New Series, No. II.)

(5.) Somewhat akin to this outbreak in its mode of causation was the outbreak of enteric fever which occurred at Caius College, Cambridge, towards the close of 1873. Dr. Buchanan's report on this outbreak is such a model of painstaking research and sound reasoning, that, apart altogether from its intrinsic value as a contribution to the etiology of fever, it ought to be read by every medical inquirer as one of the most lucid expositions in the domains of medical logic. Without detailing at any length the various interesting phases of the inquiry, it will be sufficient here to state that the cases of fever numbered 15, that the incidence of these cases was wholly upon the 112 students who were resident in the college, and that 12 out of the 15 cases were confined to 63 students, residing in a particular part of the college, namely Tree Court. The buildings connected with this particular court had been erected only four years previously, and such an amount of care had been expended on the sanitary arrangements that any injury to health arising from drains, sewers, or water-pipes, seemed well-nigh impossible. Nevertheless, the chances as a matter of *a priori* probability were as 24 to 1 that the cause of fever depended upon some condition peculiar to Tree Court, and not operative, or only operative to a very limited extent, in other parts of the college. After considering all the more usual ways in which enteric fever is known to be spread, and finding that none of them could account for the intensity of the incidence of the outbreak in Tree Court, Dr. Buchanan's suspicions were directed to the water-supply. Now, the water-supply of the college was taken from a surrounding 5-inch main at six different places, and at one of them, namely at the Gate of Humility, there was a branch main which supplied Tree Court and no other part of the college. In short, the area of this particular water distribution was the area of the fever, and although there was no doubt that the quality of the public water-supply was good, this was no argument against a "local contamination in a local service." It had struck Dr. Buchanan at an early stage of the inquiry, that the closets in Tree Court were the only closets in the college which were not provided with cisterns, but were supplied with water direct from the high-pressure constant main; and on further inquiry the following facts were ascertained:—(1) That, according to the servants, there was occasional intermission in the constant service of water-supply; (2) that there had been two actual intermissions during the term, one of which occurred about October 25th, or a fortnight before the first case, and the other certainly on November 1st, a fortnight before the date of the second, third, and fourth attacks; and (3) that although the mains were supplied with valve-taps which were believed to prevent any regurgitation of air or water, it was clearly proved by experiment that there was a reflux of air and water into the main when the water was turned off, and that the valve-tap was useless in this particular instance for the purpose for which it was intended.

Of the closets in Tree Court, two were found to be connected directly with the water-main which supplied drinking water for the whole of the court, and it is on the structural arrangements of these closets that the chief interest of the inquiry depends. One was situated in the basement of the porter's lodge, the other in the staircase, at an elevation of about 30 feet above the surrounding water-main, and about 5 or 6 feet above the level of the former. Both closets were of similar construction, and both were considered to have assisted in contaminating the water-supply, but from its higher elevation there was greater probability that the closet in the staircase played a much more direct part than the one on the basement. This closet was ascertained to be of the S-bend pattern, but in addition to the pipe communicating directly with the pan, there was found to be a smaller branch pipe dipping into the opening of a second S-bend, which was also connected with the soil-pipe, and which was intended to drain the "safe" of the closet in case of its being flooded. There were thus two channels through which influx of air could take place when the water-supply became intermittent, and in the case of the smaller branch there was the further possibility of liquid filth being sucked into the water-main under certain conditions. At all events, the air which thus entered "must have been essentially sewer air," and in this case the danger of

Such air forcing its way through traps was greatly increased by the circumstance that the sewer in the neighbouring street was unventilated, and that between the sewer and the closet there was no opening or trap of any kind connected with the excrement pipe or drain. It was further discovered that during the month of October this sewer received the discharges of patients suffering from enteric fever in other parts of the town, so that there was the probability of the sewer air having been at the time specifically contaminated. Lastly, and this is a most significant feature of the inquiry, Dr. Buchanan thought it desirable that the smaller branch pipe and part of the other pipe should be submitted to chemical examination, it having been observed that the end of the former was crusted over with a dirty-looking layer, and that the inside of both was lined with deposit. The analysis was accordingly made by Dr. Dupré of Westminster Hospital, who certified that the dirty-looking layer consisted of "a very large proportion of nitrogenised organic matter, and a very considerable proportion of phosphoric acid," and that he had little doubt that it was derived from "water strongly impregnated with fæcal matter." The deposit inside the pipes was of a similar character, so that, as Dr. Buchanan puts it, "Dr. Dupré's results show, first, that (as circumstantial evidence appeared to indicate) excremental matter actually had entered the water-pipes of the staircase closet, and secondly, that it had in fact (what had before been suggested as a possibility) entered the water pipes as a liquid. In no other way can the presence of phosphates in those pipes be accounted for."—(Mr. Simon's *Reports*, New Series, No. II.)

(6.) While there can be little doubt that this particular mode of enteric fever propagation is much more frequent than is usually suspected, the following outbreak will suffice to show the dangers which threaten any town where closets directly connected with water mains are numerous, and where the water-supply is intermittent:—During the latter half of the year 1874 an epidemic of enteric fever prevailed in the town of Lewes, of such severity that out of a population of about 11,000, nearly 500 cases had occurred, and as many as 104 of these took place during the last week of October. Dr. Thorne, who was appointed to report upon this outbreak, discovered, after minute inquiry, that "it was due, in the first instance, to pollution of the town water-supply by water drawn from the Ouse, which receives the town sewage, but mainly spread by suction of polluting matter into the water-pipes of an intermittent water service." So soon as it became clear that the epidemic was not only favoured, but practically insured, by the intermittent water-supply, Dr. Thorne urged the necessity of a constant service, and when this was obtained the epidemic became virtually arrested.—(Mr. Simon's *Reports*, New Series, No. IV.)

Although in these several epidemics there was no direct evidence to show that the outbreak depended, in the first instance, on the presence of the enteric poison in the sewage which contaminated the water, it is nevertheless noteworthy that cases of the fever were more or less common in the several localities previous to the outbreak. In the following two instances, however, investigated by Dr. C. Albutt of Leeds, and reported by him in the *British Medical Journal*, the evidence is beyond doubt, not only that the poison found its way into the drinking water, but that this was the sole cause of the outbreak. In the one case, which occurred at Ackworth, near Pontefract, in March 1870, it was found that the area of the outbreak was limited to a part of the village and school supplied by water from a certain well. The water, on analysis, gave rather more than 5 grains of organic matter, 6 of odium chloride, and an unusual amount of nitrates and itrites; and it was further ascertained that though it must have been contaminated with sewage previous to he outbreak, no cases of the disease appeared until a atient was brought home to the village who was suffering from the fever. The discharges of this patient were hrown on loose ground, which drained into the water of he well.

The other instance occurred at Bramham College, Yorkshire, in March 1869. It appears that two of the upils were laid up with enteric fever in February, but ircumstances showed that they must have contracted the disease before their arrival at Bramham. Towards the nd of March 19 fresh cases occurred, and all of them bout the same time. This sudden outbreak clearly ointed to some common cause which must have been in peration, and it was then discovered that the well used o supply drinking water was contaminated by soakage rom a soft-water tank, into which sewage matter had assed from a broken water-closet pipe. The discharges f the first two patients had also passed into this tank, nd had doubtless been the cause of the outbreak. Anther important fact connected with this outbreak was he distribution of the disease amongst the pupils, it being onfined to those who drank water, while those who rank beer escaped. As the same water was used for ooking purposes, it would thus appear that the poison ust have been destroyed by boiling.

In addition to these two instances, the following outreaks are strongly corroborative of the view which is aintained by many that the disease is essentially a ecific disease, and can only be propagated by means of specific contagium:—

(*a.*) In 1872, an outbreak occurred at Nunney, a village near Frome, and Dr. Ballard, the Local Government Inspector, who was sent to investigate the causes of the outbreak, thus states the conclusions deducible from his inquiry:—“1. That the fever at Nunney was enteric; 2, that it was brought into the village from a distant place by an individual whose evacuations, and those also of others attacked in the same and in the adjoining house, found their way into the Nunney brook, at the upper part of the village; 3, that the fever spread in the village in consequence of the villagers habitually drinking the water of the brook thus contaminated, which water was still further polluted with the sewage of the village itself, containing, if not the actual excrement of the sick, yet certainly matters washed out of their soiled linen, and also more or less of their liquid evacuations; 4, that at the time of my visit, actual excrement from cases of enteric fever was finding its way into the brook at a hamlet only half a mile above the village of Nunney.” —(*Med. Times and Gazette,* 1873.)

(*b.*) The outbreak at Over Darwen, which occurred towards the close of 1874, is alike remarkable for its terrible severity and for the thoroughness with which the cause of the outbreak was traced to its origin. According to Dr. Stevens, who was appointed by the Local Government Board to inquire into and report upon the epidemic the first case occurred at a house some considerable distance from the town, but not very far distant from the public water-main. The patient having contracted the disease elsewhere, afterwards came home ill, and died there. On first inquiry it was stated that the water supply could not by any possibility be polluted by the excreta from this case, but subsequent investigations rendered it only too apparent that here lay the whole cause of the epidemic. It was discovered that the drain of the *closet* into which the excreta of this patient were thrown crossed the line of the water-main, and though special precautions had been taken by way of cementing and the like to prevent any leakage, it was found that the drain had become choked up, that the cement had given way, and that the contents of the drain were sucked freely, indeed regularly, into the water-main. No doubt the general filthy condition of the town greatly aided in propagating the epidemic after the specific contagium had been distributed by means of the water-supply, but the terrible rapidity with which the disease spread pointed clearly to specifically polluted water as being the prime cause of the epidemic. Out of a population of about 22,000, 2035 people were attacked within a very short period, and of these 104 died.—(*Sanitary Record*, 1875.)

(*c*.) In the small village of Lausen, in Switzerland, there occurred an outbreak of enteric fever in 1871 which proved that even filtration through a considerable track of porous soil will not purify water which has once been specifically tainted. It was found, when the outbreak was investigated, that all the houses in the village, with the exception of six, were supplied with water by means of wooden pipes, from a certain spring, and that the outbreak was confined to the inhabitants who drank this spring water, the other inhabitants, who drank well-water, having entirely escaped. That the disease had been introduced by the spring-water was made clear by the following facts:—Behind the village there is a hill about 300 feet high, the westerly spur of which extends into a small side valley, and through this valley runs the Furler brook. Connected with this brook there were the latrines of several scattered farm-houses, in one of which four persons had suffered from enteric fever in the months of June and July. Although at first sight it did not seem possible that there could be any connection between these cases and the outbreak at Lausen, it was ascertained that when the meadows in the Furler valley were watered by damming up the brook, the spring increased in amount, and that when they were thus treated in July, it yielded a turbid and bad tasting water. Not long afterwards, namely, on August 7, 10 inhabitants were attacked, and in nine days more, 57 persons were prostrated with the disease, the number reaching to 130 at the end of October. To prove that the Furler brook could contaminate the spring at Lausen, the experiment was tried of putting common salt into the brook, when it was discovered that the spring water became quite briny.—(*Deutsch. Arch. für Klin. Med.*, 1873.)

(*d.*) In the early part of the present year (1879) there occurred a severe outbreak of enteric fever at Caterham and Redhill in Surrey, in which, within a period of about six weeks there were about 370 cases and 21 deaths. The outbreak was investigated by Dr. Thorne, and his report, apart from its painstaking nature, is of special interest, inasmuch as the disease was brought about under conditions which stand alone in the history of such epidemics. Before Dr. Thorne commenced his inquiries, Mr. Jacob, the medical officer of health for the combined Surrey sanitary districts, had come to the conclusion that, as regards Redhill at least, which was under his supervision, there could be little doubt that the disease, judging from its incidence, was associated with the public water-supply. That supply, like the supply for Caterham, was derived for the most part from deep wells belonging to the Caterham Waterworks Company, and after inquiring into other probable sources of the disease, such as the drainage and milk-supply, the evidence became quite conclusive that it had been caused by the use of this water. But this view received no support, either from consideration of the source of the supply, nor from its course or mode of distribution. It was derived from wells over 500 feet in depth, there was no evidence that there had been leakage into them from any neighbouring cesspits, the supply was constant, and no accidental contaminations could be ascertained connected with the mains. But while the probable causation of the epidemic was thus being gradually narrowed, certain circumstances came under Dr. Thorne's notice which led to inquiries in quite an unexpected direction. It appears that during the latter part of 1878 and the beginning of 1879 the Caterham Waterworks Company constructed an adit from one of their old wells leading to a new bore which was then being sunk. A number of men were employed in the construction of this adit, and inquiry was made as to whether any of them had ailed while the work was going on, when it was ascertained that one of them had left the work some time in January, and was believed to have been ill. This man was sought out by Dr. Thorne and Mr. Jacob, and, on being questioned, stated that he worked in the adit, that up to January 5th he was quite well, but about that date began to suffer from diarrhœa, aching pains all over, loss of appetite, shiverings followed by feelings of feverish heat, and gradual prostration. Nevertheless he continued at his work up till January 20, the diarrhœa all the while being of a most persistent character, and so liquid at times that it occasionally "ran from him." While the work was going on it was expected that all the men who were employed in the adit should make such preparation before descending the well that no occasion should exist for relieving themselves below, but should any such occasions arise, the buckets employed in excavating were to be used. Now, this man admitted that he was compelled to evacuate in the adit at least two or three times each shift, and though he denied that he ever did so without using a bucket, "there were undoubted means by which his evacuations could have found their way into the water." Although he was not attended by any medical man, there could be little doubt, therefore, that all this while he was suffering from a mild form of enteric fever, and it was further ascertained that on December 25 and 26 he paid a visit to some friends in Croydon, where he had undoubted opportunity of contracting the disease. All these circumstances are then summed up as follows:—

"Here then were the stools of an enteric-fever patient, from about January 5 onwards, getting into the Caterham Company's water, and distributed with that water to the district served by the company.

"Now we know from ample experience that enteric fever is produced, and produced with the maximum of certainty, when the specific evacuations of that disease are consumed by a population. Again, it is a matter of experience that where enteric fever has been conveyed through water, some fortnight has to elapse between the distribution of the water and the occurrence of the disease among the community served by it. But a fortnight after January 5 is the very day when the first case of fever occurred, and during the fortnight following upon the period January 5 to 20, *i.e.*, from January 19 to February 3, the disease became widely spread throughout Caterham and Redhill; the distribution of the fever being limited, as we have already seen, to houses supplied with the water of the Caterham Company. There can, I think, be no doubt but that we have in the man J. K. the cause of the disease which followed."

There are other points of great interest in this masterly report, some of them explaining what at first sight might be called the capricious spread of the disease, but all of them go to prove that the evacuations of this workman were the sole cause of the epidemic, while the remedial measures which Dr. Thorne recommended by way f pumping, cleansing, and disinfecting the wells and adits ere energetically carried out by the Company, and folwed by the complete cessation of this unique outbreak.

But in country districts there occur many scattered ases of enteric fever, which, although they have a water rigin, cannot be traced to specifically polluted water. ccording to my own experience, and it accords with that f Dr. Fox of Essex, and many other health officers who ave studied the etiology of enteric fever in rural districts, he disease is frequently produced by drinking water hich is found to be polluted with animal matter, but ot with specifically tainted matter.—As regards these ases, the most careful inquiry has failed to discover any onnecting link between them and pre-existing cases, hile in all of them it has been found that the well-water as been polluted by leakage from some cesspool, privy, r drain. It may be said, therefore, that though they are ssentially pythogenic, they are not specific. All this, owever, will be discussed more fully in a subsequent hapter (see Chap. XIV.)

3. *Diphtheria.*—Although the etiology of this disease, specially as regards several recent outbreaks, has been by o means clearly established, there is a growing preponlerance of opinion that it is much more frequently ssociated with polluted water than is generally supposed. The great majority of the sporadic cases which have come nder my own notice have occurred at houses where polluted well-water was the only cause which could be discovered, and from the answers sent in reply to the circular issued in 1878 by the Society of Arts with reference to our National Water Supply, it appears that there are a good many other medical officers of health who hold similar views. In the recent outbreak at Kirkella in Yorkshire, which was investigated on behalf of the Local Government Board by Dr. Blaxall, there was

reason to believe that the water-supply of the school had been implicated in the causation of the diseases, while other outbreaks have been instanced having a similar probable origin.

4. *Dysentery.*—The instances of outbreaks of this disease which have been traced to the presence of animal impurities in drinking water are so numerous, especially in Eastern countries, that the mere mention of the fact will suffice.

5. *Diarrhœa.*—In addition to outbreaks occasioned by direct sewage contamination, there are several recorded cases of the following description:—In the Salford Jail there was a sudden outbreak of diarrhœa of a choleraic type, which affected 57 per cent of the prisoners, while of the officers and their families, who were distributed throughout the building, not one was attacked. The food of the prisoners was examined and found to be good; it was evident also that the air did not contain the cause of the disease, for both classes were under the same conditions in that respect; suspicion was therefore directed to the drinking water. It was then discovered that, though the water supplying all parts of the prison was derived from the same source, there was one cistern for the use of the officers, and another covered cistern to supply the prisoners, and that the untrapped overflow-pipe of the latter communicated with an open sewer. On the day of the outbreak the water from this cistern was observed to be coloured, and to taste unpleasantly. It had obviously absorbed sewer-gas, which had ascended through the overflow-pipe; and that this had been the real cause of the disease was confirmed by the fact that the outbreak disappeared almost as rapidly as it commenced, when the cistern was emptied and the pipe efficiently trapped.—(*Second Report of the Medical Officer of the Privy Council.*)

According to my own experience, much of the diarrhœa hich prevails in country districts during the summer nd autumn amongst children is due to polluted water runk either as it is drawn from the well or when mixed ith milk.

Concluding Remarks.—Although an attempt has thus een made to classify roughly the hurtful impurities of ater, and the diseases which they may severally pro- uce, it need hardly be said that in the great majority of nstances of faulty sanitation connected with water-supply, here is often a combination of impurities and of diseases oth. For example, the analysis of waters which have roved to be decidedly injurious shows that in general he impurities are numerous; and, on the other hand, ot one but several diseases may be either directly pro- uced or indirectly influenced by them. And this diffi- ulty of apportioning to special impurities their special ffects is frequently increased by the presence of other auses of disease. Thus, the water may not only be pol- uted, but the supply may be scanty; and thereby give ise to great want of cleanliness of the person, of clothes, f cooking utensils, and of the general surroundings; hile overcrowding, defective sewage-removal, badly venti- ated drains, and other causes of disease, may also co- perate in seriously affecting the health of a community nd largely increasing the death-rate.

Amongst other diseases which have frequently a water origin may be mentioned ulcerated sore throat, low ever, and erysipelas. Indeed, in purely country districts what is known as low fever is essentially a filth fever, and is found to be produced in the great majority of instances by polluted well water.

It would also appear that the prevalence of calculous disease and gravel bears a close relation to the amount of lime and magnesian salts contained in the drinking water of certain parts of the country. This disputed subject has been carefully investigated by Dr. Murray of Newcastle-upon-Tyne (*Brit. Med. Journal,* 1872); and his statements, together with the cases which he adduces, are strongly corroborative of this view.

Finally, it has to be noted that several of the entozoa find their way into the body of the agency of drinking water, as for instance the *Bothriocephalus latus* and the *Ascaris lumbricoides.* The latter, which is known as the *round* worm, I have found to be very common in districts where the water-supply is chiefly obtained from shallow dip wells.

CHAPTER IX.

DWELLINGS.

E vast importance attaching to the sanitary conditions
dwellings has already been frequently alluded to in
vious chapters. Diseases arising from unhealthy site,
m insufficient ventilation or overcrowding, from tainted
stinted water-supply, from defective drainage, or from
umulations of filth, are all of them associated with
bitations which are faulty in their situation, construc-
n, or management.

SECTION I.—SITE.

In choosing a site, special attention should be paid to
nature of the soil and the general conformation of the
und. The soil, if not dry, should be drained, and all
llows wherein water is likely to lodge should be avoided.
here possible, the aspect should be open and cheerful,
that an abundance of light and a free movement of air
be obtained.

In towns, a great evil sometimes arises from building
rubbish containing vegetable matter which has been
ed to fill up the excavations made in brickmaking.
us, in 1872, Mr. Crossby reported that the high rate
mortality in Leicester during the autumnal months was
iefly due to an annual visitation of infantile diarrhœa
hich prevailed in parts of the town built on such refuse;
d he distinctly attributed the disease to this cause. It
also worthy of special notice, that this opinion has

recently been fully corroborated by the very elaborate and painstaking report presented by Dr. Buck and Mr. Franklin on the epidemic of diarrhœa which prevailed in that town during the summer and autumn of 1875. Further, the evidence of Drs. Parkes and Sanderson, in their valuable report on the sanitary condition of Liverpool, though negative as regards the effects of cinder-refuse on the health of the occupants of houses built upon it, clearly points to the conclusion that such a soil is objectionable, at any rate when first laid down. With regard to this point, they advised the Town-Council to adopt the following rules:—

"1. No excavation should be used for the reception of cinder-refuse unless it is efficiently drained. This appears to us to be of especial importance in relation to the filling up of brickfields. It is well known that the whole of the surface of clay is never removed, and there is always sufficient to form an impermeable basin, in which, in the absence of drainage, water constantly collects. We hold it to be of the greatest importance, for the rapid decomposition of whatever offensive material may exist in the 'cinder,' that it should be able to become dry. The only way in which this can be promoted or secured is by efficient subsoil drainage.

"2. As the vegetable and animal matter contained in the cinder-refuse decays and disappears in about three years, and is virtually innocuous before that time, we recommend that places filled up with cinder-refuse shall not be built upon for at least two years from the date of last deposit."

They also advised that road-scrapings should not be mixed with the cinder-refuse, and that the scavenging department should be more careful with regard to the selection of material.

It need hardly be said that wells sunk in made-up s of this description can only yield a water which is ly polluted and altogether unfit for use.

SECTION II.—STRUCTURAL ARRANGEMENTS.

In building on a site which has already been occu- , great care should be taken to make a thorough nination of the ground, so that no cesspits, rubble ns, or old wells, may escape notice. Every old drain ld be taken up, all removable filth cleared away, and y pit thoroughly cleaned out and filled in with rete.

Unless absolutely necessary, no drain should traverse basement of a house; and when it is necessary, as n houses are joined together in streets or squares, y such drain should be made absolutely air and r tight. Pipes of glazed earthenware are best suited he purpose. They should be laid on a bed of con- made with ground lime or cement, securely jointed, covered with concrete. They should also be pro- d with full means of ventilation at either side of the ment. When they pass through foundation walls it lvisable that relieving arches should be turned over n, because it often happens that they become broken ettlements, or during the consequent underpinning. side the building the pipes should be laid in a water- t trench of clay puddle or concrete, and should lie r full diameters below the subsoil of the basement, in r that the lowest parts of the house may be efficiently ned.

To facilitate inspection, the outside track should be ided, at suitable intervals, with access pipes. These of various patterns, but all of them permit an easy ning into the drain, so that deposits or obstructions can readily removed. To prevent the formation of such deposits, all house drains should be regularly flushed. (For further particulars, see Chapter on Removal of Sewage.)

Where a cesspool is required to receive the sewage of a country house provided with water-closets, it should be situated at a safe distance from the building, made perfectly water-tight, and be abundantly ventilated. The plan of construction should be on the liquid-manure tank principle, the walls being of brick-work set in cement, surrounded by a clay puddle, and lined inside with a coating of cement. Both roof and bottom should be arched, the roof provided with a manhole, and the bottom built with a fall towards one end, where a pump could be fixed. The depth should not exceed 6 or 7 feet, otherwise the increased hydrostatic pressure would necessitate expensive walling. To separate the solids from the liquids, a galvanised iron wire diaphragm or grating should divide the tank into two parts. All cesspools should be regularly and frequently cleaned out, and it is of the utmost importance that the drains should be trapped, and the soil-pipe ventilated. If the cesspool is situated in a field or orchard some distance from the house, the liquid contents can frequently be got rid of by constructing an overflow pipe leading into sub-irrigation drains either with or without a flush-tank. (See Chapter XI.)

If the water-supply is to be derived from a well, the well and cesspool should be widely separated. In case of accidental leakage, it is also necessary that the well should not be near the house drains. To exclude subsoil water, the upper part of a well should be clay-puddled, or made otherwise water-tight, and the mouth should be protected against the entrance of surface water. Every well should be ventilated and provided with a manhole for purposes of inspection and cleansing.

After having secured dryness and healthiness of subil, the next point of importance which has to be kept in ew is the isolation of the area upon which the proposed velling is to be erected from the subsoil, and this can be ected in the cheapest and best way by using concrete. order to prevent damp from rising into the walls, a mp-proof course should overlay the whole of the foundans. Two or three courses of slate laid in the best ment will answer the purpose, or, if external symmetry the damp-proof course be made a desideratum, tiles de of highly vitrified stoneware should be employed. hen there is a basement storey, it should be isolated m the ground by an open space. The entrance of derground damp may also be prevented by constructing at are called dry areas; that is, by leaving a space tween the main wall and a thin outer wall, which reaches the ground level, the two being joined together here and ere by stretching bricks.

As much of the dampness in walls is due to driving et, well-planned houses are now often built with hollow alls, in which case ties or bonding bricks must be laid in regular intervals, to render the strength and stability the twin walls equivalent to a strong single wall. ith single walls, built of soft porous material, the effects driving wet may be obviated by slating or tiling them, by applying to the outer surface one or other of the veral patent waterproof compositions which are well commended.

Perforated bricks should be introduced at suitable disnces in the outer walls, to admit air to the joists and eneath the flooring.

One of the gravest faults in the construction of even he better class of houses in the present day is the little ttention which is paid to the position and arrangements f water-closets. They are too frequently situated in out-of-the-way corners, where only borrowed light can be obtained, and efficient ventilation is impossible. The best position is in an isolated block, built tower-fashion, and abutting against the outer wall of the house, with a closet on each floor and the supply cistern on the top. There should be an anteroom or passage between each closet and the house, large enough to admit of sufficient cross ventilation by means of open windows or windows provided with ventilating panes. A double set of doors would be required,—one leading into the house and the other cutting off the passage from the closet. The closet-seat should face a window in the outer wall, so that abundance of light may be secured for inspection with regard to cleanliness, and direct draught from the window be avoided. The window should extend up to the ceiling, and have double sashes. The closet may be permanently ventilated by keeping the top sash drawn down, or by air-bricks inserted immediately beneath the ceiling. In smaller-sized houses the closet may be simply projected from the building, with the seat facing the door, and with two opposite windows reaching to the ceiling between the seat and door. Cross ventilation and sufficient light would thus be obtained; without the interposition of an anteroom.

There are so many kinds of closets, well arranged in all their details, that it is difficult to say which of them are most to be recommended. There are others, again, such as the round hopper closet-pan fixed into an ordinary sigmoidal bend, which cannot be sufficiently condemned, unless worked by a very high pressure of water;—they are constantly getting foul, and it is seldom that the whole of the excreta are removed; indeed, they can seldom be kept clean unless they are regularly flushed by a bucket or pail. Generally speaking, those closets are the best which provide for good flushing and rapid and complete removal of the excreta, without permitting reflux of foul air. Every closet, unless it be flushed by hand, should be provided with a cistern, preferably of the waste-preventing kind, because it is of the utmost importance hat there should be no direct communication with the water main. It has also to be pointed out that the closet hould not be supplied from the same cistern which sup- lies the drinking water. The pan should be roomy and ade of white glazed earthenware; the machinery should ork easily and not be apt to get out of gear; and the at should be so framed as to come asunder readily to rmit of inspection. Amongst closets which have been und to work satisfactorily may be mentioned the Excelsior Water Closet," manufactured by Mr. Bostel, ighton, which has gained the medal of the Sanitary stitute; the "Holborn Closet" and "Universal Closet," th manufactured by Mr. Finch of the Holborn Sanitary orks; the "Patent Valve-Closet and Trap" of Mr. nnings; the "Elastic Valve-Closet;" "Underhay's gulator Valve-Closet;" Banner's Closet; Winn's Closet; d Dodd's Closet.

As soil-pipes communicate directly with the drains, y should be carried up to the highest part of the roof, d be of the same diameter throughout. Efficient venti- ion of the drains is in this way secured at a most portant point, and the pipe from the closet trap can be nected with the soil-pipe without interfering with the ward current of sewer-air. If the soil-pipe cannot be ried straight up to the top of the house, the bends or gles should be made as obtuse as possible, and in any e it should not be plastered or built into the wall, but t free for inspection throughout its whole track. It is vious that, were this plan universally adopted, there uld be no pressure of sewer-gas against the closet trap, d therefore little or no risk of its entering into the ouse by this channel.

It has been urged, by way of objection against this plan, that, where houses are closely packed together, a are of different elevations, the sewer-gases dischar from the pipes of the lower houses would find their w into the higher, and thus become not only a nuisance l a source of danger. With ample sewer-ventilation, ho ever, the objection does not hold good, because the se air is so diluted as to be inoffensive and comparativ pure; besides, in cases where it is proved to be offens some such mutual arrangements as are adopted w regard to offensive chimneys would meet the difficulty

With regard to all other pipes, whether waste-wa pipes, sink-pipes, or pipes from lavatories, it should laid down as a rule that none of them should lead dire into either the soil-pipe or drain. They should be car outside the house to within 12 or 18 inches from ground, and deliver on to the grating of a yard or gu trap. Such a trap might be ventilated by the rain-w pipe when the rain-water is allowed to flow into the dr or through a charcoal tray, if it become offensive. although the sewer-gases are in this way prevented f entering the house, it is still necessary that the sink other pipes should be trapped. Scullery and sink pi for example, will require article-intercepting traps, pipes to lavatories or baths must be provided with syp traps to prevent the ingress of cold air.

All traps on house-drains should be ventilated ei by pipes carried to the roof or parapet of the house by what is called direct ventilation. Unless prote in some such way, they are comparatively useless. Chap. XI.)

Details concerning the ventilation and warming o house have already been given in Chapter IV., and only points which need be repeated are—the importa of constructing a separate extraction flue for each r in the chimney-stack, the desirability of inserting ve lating fire-places, and the great advantage of securing that he products of gas-combustion be conveyed by special hannels into the outer air.

It is needless to say that the rooms in a well-contructed and healthy house should be spacious, airy, and ight. The windows should reach to within a short disance of the ceiling, and should always be made to open. t is preferable to have them glazed with plate glass, to conomise heat. No single bedroom should be of less imensions than 1000 cubic feet, nor should any bedtead be fixed in a recess.

SECTION III.—DWELLINGS FOR THE POORER CLASSES.

In constructing buildings for the poorer classes, the reat difficulty, encountered at the very outset, consists in roviding the necessary accommodation with the requisite anitary arrangements at a cost which will allow of a fficiently low rental. In towns the original cost is reatly increased by the high price of land, but even in untry places, where a site can be procured at a cheap te, the cost for the erection of a cottage of the humblest etensions will entail a rental which many a labouring n can barely meet. Where the ground rental is low, cheapest and most commodious form of labourer's tage is one without any upper storey. Thus, according Mr. Allen, in his manual on Cottage Building, a cottage sisting of a living-room for general every-day use, a bedm for the labourer and his wife, a bedroom for boys, a droom for girls, a small wash-house, a store-room, and set, could be built for £100, provided all the rooms on the ground-floor, and that two such cottages be ged side by side, so as to be spanned by the same f, and contained within four walls, forming a simple rallelogram. The row of cottages proposed by Dr.

Hunter in the Seventh Report of the Medical Officer to the Privy Council, provided for a front and back kitchen in each cottage, and two bedrooms overhead. The kitchens were to be paved with brick or tile, "the front about 11 feet by 11, by 8 feet 6 inches high; the back about 11 by 8 feet 6 inches. Ceiling would be unnecessary. There should be five doors only, the closet under the stairs one, each bedroom one, and two house doors. There should be four sliding windows, a grate with an oven, a boiler in the back kitchen, a little fireplace in one bedroom, and a Welsh slate roof, the bedrooms being ceiled.

"Such houses might be supplied for £50, or £1500 for the thirty."

In a paper read before the Farmers' Club in 1874, Mr. Howard of Bedford states that, some few years previously, he built a block of six cottages for his labourers entirely of concrete. The walls were a foot thick, and in consequence of the impervious nature of the material they were warmer and drier than ordinary brick-work. Each cottage contained three bedrooms, and each was provided with an earth-closet at the end, but accessible from within. Exclusive of the closets, the cost of the whole block was a little over £600, or £100 per cottage.

According to the design by Mr. Birch, which obtained the award of the Society of Arts in 1864 for premiums offered by Mr. Bailey Denton, the estimated cost of a pair of cottages was £203, including every requisite necessary to render them complete and fit for occupation. On the ground-floor it was proposed that there should be a living-room 12 feet 6 in. by 12 feet; a scullery, containing a copper for washing and a sink, 10 feet 5 in. by 7 feet 6 in.; and a small pantry and place for fuel opening into the scullery. On the chamber floor there were to be three bedrooms with a floor-space respectively

12 feet 8 in. by 8 feet 6 in.; 7 feet 8 in. by 8 feet in.; and 9 feet by 8 feet.—(See *Builder*, 1864.)

Owing to the increased cost of materials and the rise wages, it is very likely that the above estimates would found to be somewhat too low for the erection of milar cottages in the present day, but if built in blocks pairs, I am credibly informed that good cottages with ree bedrooms can still be erected for about £100.

In these plans, and in fact in almost all plans for ttage construction, the cubic space allowance is very nited, so that overcrowding, to a greater or less extent, sure to prevail at times. Cottages which are scarcely omy enough for a married couple and two or three ildren become occupied by much larger families, or the mily increases in number year after year, while the droom accommodation remains the same. The initial ace, therefore, should be ample enough to meet the quirements of, at any rate, moderate family increase; nd when a number of such cottages are built in the me locality, they should be of different sizes, to suit nall and large families alike. The kind of closet best ited for country cottages is some modification of the y system, while the slops, if they do not discharge into llage drains, should be utilised in the garden, or disposed by subsoil irrigation where that is possible. All this, wever, will be discussed more fully in Chapter XI.

In large towns the house accommodation for the ouring classes must necessarily be supplied in a great asure by what are called tenements, but in this case ecial attention should be paid to sanitary arrangements, h as closet accommodation, water supply, ventilation, d general cleanliness of premises, and a copy of rules by-laws should be prepared and handed to each occunt.

Of equal importance with the construction of dwellings for the labouring classes is the far more difficult problem of repairing and improving the unhealthy abodes which, in town and country village alike, increase the annual rate of mortality to an extent that can hardly be estimated. It is true that the law already prohibits the inhabitation of the worst class of dwellings, such as damp, dark, underground cellars; but there are other dwellings, so numerous that their immediate demolition would deprive a large proportion of the lower classes of shelter, which no alterations or improvements can render healthy. They are either situated in narrow, dingy alleys, or huddled together in close courts, so as to be practically unventilable, or their internal condition and constructural faults are so grave as to be beyond remedy. Nor are these the only sanitary defects connected with them which have to be condemned. It is in these very dwellings that the filth and poisonous effluvia due to overcrowding are constantly accumulating, and where the germs of disease find a fitting soil for their development. The departmental reports of the Privy Council afford numerous instances of such a state of things, and notably those of Drs. Hunter, Stevens, and Buchanan.

No doubt the carrying out of the provisions of the Artisans' Dwelling Act of 1875 will eventually bring about a marked improvement in this respect in many of our cities and large towns, for hitherto the difficulty of dealing with what is called "surface-crowding" has thrown great obstacles in the way of reaping to the full extent the advantages to be gained from lessening the indoor overcrowding. In the worst parts of Liverpool, according to Drs. Parkes and Sanderson, nearly 1000 persons are huddled together in one acre of ground, and in other towns, such as Glasgow and Greenock, the number per acre in some districts is quite as great. It is clear, therefore, that no improvement in the dwellings, nor any increase in the amount of cubic space per head, will render the ventilation as satisfactory as it should be, when so many houses are packed together in such a limited space. Demolition of old houses, the displacement of the population into blocks of model dwellings, or into houses put into serviceable repair, and the opening of new streets, are all necessary.

In country districts, where there is far less excuse for the existence of these evils, it has been found that in reality they are almost as glaring and wide-spread as in towns. The elaborate report of Dr. Hunter on the State of the Dwellings of Rural Labourers (see *Seventh Report of Medical Officer of Privy Council*) may be quoted in proof of this statement. In all, 5375 cottages were reported upon. Of these, 2195 contained only one bed-room; 2930 contained two; and only 250 more than two. The number of persons resident in them, including adults and children, was 24,770, giving an average of 4·6 ersons to a house, or 2·8 to a bedroom. In the single-edroomed houses, the average number sleeping in the edroom was 4, 2·2 of whom were adults and 1·8 child- n. The average cubic space for sleeping accommo- tion was estimated at 156 feet per head. The rickety ate of the great majority of the hovels permitted a eer interchange of air than in the new cottages, so that, though the cubic space per head in the latter was some- hat larger, the contained air was generally more impure. ndeed, many of the bedrooms were so much exposed to e weather, that cases of sickness, when they did occur, d to be treated in the kitchen. But the wretched nitary condition of the dwellings was even a less evil an their numerical insufficiency. It was found that any landlords pulled down the cots on their estates when hey fell into decay, without providing others, and thus orced the labourers to find house-room in already overcrowded hamlets. As a consequence, this huddling together of human beings not only presented numerous *foci* for the development of disease, but rendered the limitation of any contagious diseases which were introduced an almost hopeless task. That such a state of things continues to exist in many rural districts, the reports of medical officers of health from all parts of the country show but too clearly, and though there can be no doubt that the improvements which have been carried out in various districts since the passing of the Public Health Act of 1872 have been very considerable, it is impossible to cope with the innumerable evils connected with defective house-accommodation in small towns and country villages until larger legislative powers are conceded. As I have stated elsewhere, I am strongly of opinion that some measure akin to the recent Artisans' Dwellings Act is urgently required for rural and small urban districts. "Let this legislative necessity be advocated as warmly as it has hitherto been tacitly admitted, and there will be no difficulty in drawing up a bill which, without unfairly interfering with the rights of private property, will give a wholesome stimulus to the discharge of public obligations; afford the requisite scope for individual or conjoint enterprise in adapting old cottages and in building new ones where they are required; and, above all, empower and impose it as a duty on sanitary authorities, which cannot be evaded, that they themselves shall carry out the necessary improvements in localities where private or conjoint enterprise, aided if you like by philanthropic effort, may prove inadequate, or where public obligations on the part of landowners are in this respect persistently neglected. But it has been urged that individual or conjoint enterprise will fail to be elicited because cottage property does not pay a sufficient percentage on the outlay. Well, I am quite willing to admit that what are called ornamental

;tages may not pay, but ornamental cottages are need-
sly expensive, and are built under exceptional circum-
ınces. What I do know is this, that substantial and
nfortable cottages can be built in pairs or in blocks,
:h containing three bedrooms, at a cost of about £100
r cottage. Then, again, it is very well known that the
ırst class of cottages, when they get into the hands of
ıall property owners, often pay as much as ten to fifteen
r cent on their outlay, so that taking into consideration
e improved and improving position of the labourer to
y a better rental, the fair return that may even now be
tained for new cottages, and the comparatively large
turn which is obtained for all cottages after being put
to habitable repair, there is every reason to believe that
ere will be no lack of private or public enterprise in
e shape of local building and improving societies, pro-
ded only the requisite facilities for such enterprise be
galised by Act of Parliament."—(See the Author's
ımphlet on *Sanitary Defects in Rural Districts, and How*
Remedy them, and Dr. Bond's *Home of the Agricultural*
ıbourer.)

Unfortunately, too many of the evils connected with
ıuse-accommodation in rural districts threaten to become
ırpetuated, inasmuch as rural sanitary authorities, unless
ıey apply specially for urban powers, have no control
er the erection of new buildings. Similar bye-laws
ıould be in force with respect to thickness of walls,
ıight of rooms, ventilation, drainage, and general sanitary
rangements, which are carried out in urban districts.
ıdeed, it is difficult to conceive why such control should
ot have been conceded to sanitary authorities without
istinction, unless it be that sanitary legislation has
itherto been halting and one-sided. It is quite true that
ıany sanitary defects connected with existing cottages
an be dealt with under the wide term *nuisance*, such

as—the repair of uneven floors, and roofs that let in the rain; the repair of dilapidated walls; the opening of closed windows; the removal of privies and pig-styes which abut against outside walls; the drying of the subsoil; the repair of drains; and the like. It is likewise true that if a house cannot be put into fairly habitable repair, the law gives power to close it; but where houses are scarce, it need hardly be said that this becomes a very serious matter, inasmuch as it either tends to increase the overcrowding elsewhere, or leads to displacement of labourers and their families, an alternative which is attended at all times with much inconvenience, and very frequently with great hardship.

In large towns this displacement of the population becomes a question which naturally affects the poorer classes to a much greater extent than in country villages. Many extensive undertakings, such as the construction of railways and new streets, while they act beneficially in making wide clearances in the crowded districts, almost of necessity conduce to overcrowding in neighbouring parts. The families that are thus rendered homeless by the demolition of their dwellings seek the nearest shelter, rents are raised in consequence of the increased demand for accommodation, and such as cannot afford to expend more than they did previously must be contented with homes even less healthy than those which they have been compelled to leave. As a compensating measure, the running of working men's trains morning and evening, between the suburbs and the town stations, although it is a step in the right direction, does not by any means meet the difficulty. Larger measures are undoubtedly required, and the more thoughtful amongst sanitary reformers are agreed in maintaining that no parliamentary powers, permitting the demolition of numerous dwellings in populous districts, should be granted unless the comanies or corporations applying for these powers provide ommensurate and improved accommodation elsewhere, nd within reasonable distances. It is true that many of e displaced population might not choose to remove to the ew dwellings, but they should have the option. Tenants, all events, would not be wanting, and that there would no financial loss is clearly proved by the profits gained private enterprise in building homes for the working-asses, although it must be admitted that numbers of ch houses, as they are run up in the present day, can arcely be pronounced habitable. Urban sanitary authoties have, however, full powers vested in them by the atutes to prevent the erection of dwellings that are nwholesome, and it is their duty to see that the accomodation and structural arrangements are in all cases tisfactory.

Concerning the duties of the medical officer of health ith regard to overcrowding and places unfit for habitaion, together with the sanitary enactments dealing with he same, see Chapter XV.

CHAPTER X.

HOSPITALS.

In large towns the position of every hospital must primarily depend on the distribution of the population, a part of the population, whose wants it is intended relieve, and hence the choice with regard to site is ofte very limited. Apart, however, from this restriction, ther are certain considerations which ought always to influence the selection of site. For example, the future hospital should be erected in as airy and open a space as can be obtained, preference being given either to the outskirts of towns or to their largest interior unoccupied spaces. According to the recommendations of the Chirurgical Society of Paris in 1864, a free area of not less than 540 superficial feet should be allowed for each patient. This would give an acre of ground for an hospital containing 80 beds. In this country, on the other hand, an acre for 100 patients has been held to be sufficient. Any defect in salubrity of site must be compensated by increased floor and cubic space.

No doubt, the most healthy site for a hospital is in the open country, with a dry and porous soil, and slightly raised above the plain to facilitate drainage, but even a stiff clayey soil can be made perfectly healthy if proper precautions be taken in asphalting or concreting the foundations, and in providing plenty of free ventilation beneath the ground-floors. While shelter from the cold *north*-easterly winds is desirable, it is an error to build hospitals on the face of a steep slope, or in any situation where there is an impediment to a free circulation of the ir. Undrained marshy ground should be avoided, nor hould houses or clumps of trees be in close proximity to e building.

For hospitals situated in the crowded localities of rge towns, convalescent homes in the country, or at the a-side, are now being provided, and with marked advan-ge to the patients.

The late discussions on hospitalism, though perhaps mewhat one-sided in giving such prominence to the test surgical results, have fully established the great hygienic lvantages which small cottage hospitals possess over the rge palatial buildings that have hitherto found favour ith the profession. It is further generally admitted that, hen large hospitals are rendered necessary, they should pproximate as much as possible to the sanitary conditions hich can only be ensured by small detached buildings. he application of this principle has resulted in the con-truction of hospitals on the pavilion system—a system hich accommodates itself to almost any site and to any umber of patients.

SECTION I.—PAVILION HOSPITALS.

In this description of hospital, each pavilion may be regarded as a separate hospital, and the impurities of every single ward are cut off from the other wards. The pavilions are united by a corridor for administrative purposes and for convenience, but are so arranged that a free circulation of air can always take place between them. In its simplest form a pavilion would consist of a single ward, with the necessary additions for administration. More frequently, however, it consists of two wards, one above the other, and, in some instances, of three wards, as in the Marine Hospital at Woolwich. Three-storeyed pavilions are objectionable, because their height necessitates a lofty corridor to unite them, and induces stagnation of the air. With two-storeyed pavilions, on the other hand, the corridor need only be half the height of the pavilions.

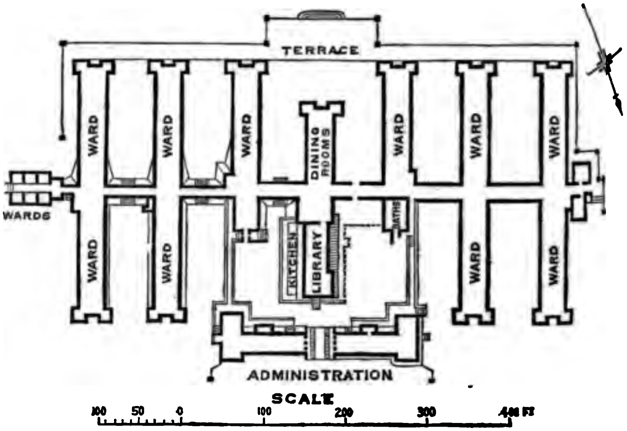

Fig. 5.—GENERAL PLAN OF HERBERT HOSPITAL, WOOLWICH. (From "Construction of Hospitals," by Douglas Galton.)

In large hospitals, such as the Herbert Hospital, th pavilions may be united in twos, end to end, with th corridor running between them, the staircase being, as i were, strung on to the corridor. The distance betwee the pavilions should be at least twice their height.

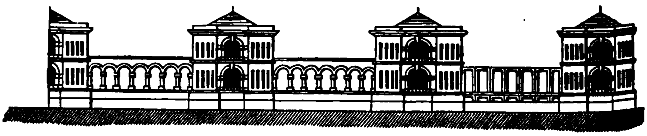

Fig. 6.—Sketch of the end of the southern Pavilions of Herbert Hospital, showing the elevation of the corridor. (After Galton.)

The basis or unit of hospital construction is the war The conditions which determine the size and form of *ward* are the following:—

1. The number of patients which it should contain.

2. The floor and cubic space allowed to each patient.

3. The arrangements for warming, light, ventilation, d nursing.

1. The number of patients in a ward will depend on size of the hospital, and, occasionally, on the nature the cases. A cottage hospital, for example, will necesily consist of small wards, and even in large hospitals all wards are required for isolating very severe or cial cases. With these exceptions, however, the mber of patients in a ward must depend mainly upon number which can be efficiently nursed at the smallest t per head. Miss Nightingale, in the Report on Metrolitan Workhouses, fixes this number at 32. She says, head nurse can efficiently supervise, a night nurse can efully watch, 32 beds in one ward, whereas, with 32 ds in four wards, it is quite impossible." Throughout ropean hospitals the number varies from 24 to 32.

2. One of the most important questions attaching to spital construction is the amount of floor and cubic ce which should be allowed to each patient, and there scarcely any question concerning which there has been much discrepancy of opinion. Thus, Dr. Todd mainned that 500 cubic feet were sufficient; Dr. Burrows, 00; the Army Sanitary Commission, 1200; and the mmittee appointed to consider the cubic space of Metrolitan Workhouses, 850. The recommendations of this mmittee further limited the cubic space allowance for rmitories to a minimum of 300 feet, and for wards conning infirm paupers to a minimum of 500 feet per ad. There is no doubt, however, that, in consequence the conflicting evidence on which the Committee had base its recommendations, the difficulties of efficiently ntilating small spaces without draught were not suffiiently appreciated; but as reference has already been

made with regard to this point, it need not be again discussed. Suffice it to say that General Morin, the greatest French authority on ventilation, to whom the disputed subject was submitted, gave it as his opinion that, even for paupers who are not ill, he considered it "necessary not to descend below 880 cubic feet of space, and besides this the condition must be imposed of renewing the air in the proportion of 1060 cubic feet per individual per hour."

That the recommendations of the Committee failed in securing purity of the air in workhouses, is shown in the reports on night-nursing which appeared in *The Lancet* in 1871. With regard to the Holborn Workhouse, for example, the report states that "there are upwards of 200 sick paupers here, of whom the great majority are unable to leave their beds. There are 240 deaths in the year, or an average of 5 per week. The wards are low, close almost to offensiveness, and over-crowded; although they may be an improvement on the style of thing which was in vogue twenty years ago, they nevertheless cut a sorry figure when compared with even the worst-built of our general hospitals." And again, with regard to the Marylebone Workhouse:—"The amount of cubic space varies from 300 to 1200 feet. In some of the wards the beds absolutely touch, and there is scarcely room to thread one's way between the rows. The atmosphere in these wards is, as may readily be imagined, anything but nice. It is true, the inmates of them are comparatively healthy, but we should think that the arrangements are well calculated to rob them of what health they have."

For ordinary hospital cases it is now generally admitted that a cubic space of at least 1200 feet should be allowed per patient, and for cases of infectious disease, or for severe surgical cases, as much as 4000, and it may be *doubted* if this be sufficient at all times.

On the superficial area per bed will depend the disance between the beds, the facilities for nursing, and the onveniences for ward administration. This, like the ubic space, has been variously estimated. Thus, in St. eorge's Hospital it is only 69 square feet; in St. Barolomew's it is 79; in the Herbert Hospital, 99; in the etley Hospital, 103; in Guy's, 138; and in the new t. Thomas's Hospital, 112. For all nursing purposes, iss Nightingale maintains that at least 90 square feet ould be allowed per bed, and this amount, according to aptain Galton, should be accepted as a minimum. Where edical schools are attached to hospitals, an extra allownce must be allotted for the requirements of clinical aching. The space must also be greatly increased in ver or lying-in wards. The height of an average-sized ard should be 13 or 14 feet.

3. For providing sufficient light and for maintaining urity of the air, much depends on the width of the ward. xperience has shown that this should not be less than 4 feet, and not more than 30 or 35. In the new Leeds ospital it is 27 feet 6 inches; in the new St. Thomas's 8 feet; and in the Herbert Hospital 26.

The ventilation of each ward should be entirely inependent of the others, and to effect this, cross-ventilation y means of open windows, aided by Sheringham valves, xtraction-flues, and ventilating fire-places, is deemed to e the most efficient. In the summer months, when fires re not required, the windows should always be kept more or less open, except during rough, blustering weather.

When a window is allowed for each bed, which is sometimes the case, the wall-space between the windows should be six or eight inches wider than the bed. In the pavilion system, however, an allowance of one window for every two beds is generally considered sufficient, the beds being arranged in pairs between the windows, and separated from each other by a distance of at least three feet. The windows should reach from within two feet or two feet six inches from the floor to within one foot from the ceiling. The space between the end wall and the first window on either side of the ward should be four feet six inches, and the space between the adjacent windows nine feet, the windows themselves being four feet six inches wide. An end window to a long ward adds greatly to its cheerfulness, and aids materially in the ventilation of the ward. The ordinary sash window, made to open at top and bottom, is perhaps preferable to any other kind. To economise heat, plate-glass should be used instead of ordinary glass.

In addition to means of ventilation provided by windows, there should be a fresh-air inlet, furnished with a Sheringham valve, placed near the ceiling and between each window, or an upright ventilating tube of the kind recommended by Mr. Tobin. When the fire-places are situated in the external walls, two or three fresh-air inlets may be provided at equal distances along the centre of the floor, and communicating by means of transverse flues beneath the flooring with the external air. Such inlets are so far removed from the beds that the currents entering through them are not felt by the patients when in bed, and they could be closed if deemed necessary during the day-time. The gratings covering them should be capable of easy removal, so that the flues may be cleaned out regularly.

The extraction-flues should be situated, if possible, on the same side of the ward as the fire-places, and should be carried above the roof and louvered. When not contiguous with a chimney, they should be provided with gas-jets to aid their extractive power. If the fire-places are situated in the centre of the ward, the extraction-flues should be placed in the opposite corners. The inlets to on-flues ought to be near the ceiling, but not in oximity to the fresh-air inlets.

fire-places best suited for infirmary wards are the ing stoves already described in the Chapter on ion. But in addition to these, or in place of he fresh air might also be heated by hot-water oiled in boxes below each bed, as recommended Parkes, or the pipes might pass along behind the , the skirting being perforated or supplied with opposite each bed, for the admission of the ir.

ry gas-jet in a ward should be furnished with a ess lantern communicating with an extraction-tube off the products of combustion, or Rickett's ven-globe lights should be used. (For particulars with o ventilation, see Chapter on that subject.)

furniture in a ward ought always to be reduced imum, and should never be cumbrous or bulky. dsteads are to be preferred to wooden ones, and rse-hair mattresses, placed on springs, to thick r woollen mattresses. All bedsteads should be t a short distance from the walls. Coverlets and should be white or light-coloured, to show dirt, ht to be frequently aired.

other points of sanitary importance connected ward are its offices, and the materials employed in tion.

rd-offices are required for facilitating nursing, and direct use of the sick. Thus every ward should tached to it, at the end nearest the door, a scullery urse's room, and, at the farther end, a water-closet ution-room. The nurse's room should be light and d large enough to be used as a bedroom. It should provided with a window, looking into the ward, poses of inspection. The scullery should be situated opposite the nurse's room, and ought to be fitted with a small range for warming drinks, preparing fomentations, etc.; a sink with hot and cold water laid on; and shelves and racks for dishes. It should be large enough for the assistant nurses to take their meals in.

The water-closet and ablution-room should be situated, one at either farther corner of the ward, and both should be completely cut off by means of swing-doors and a lobby supplied with cross-ventilation from the ward. The water-closet apartment ought to contain one closet for every 10 beds, or 3 closets for 32, and should also be supplied with a sink and a urinal. Instead of a handle and plug for turning on the water for flushing, it is preferable to have a self-acting water-supply connected with the door, because some patients are careless, and others are too feeble to raise the handle.

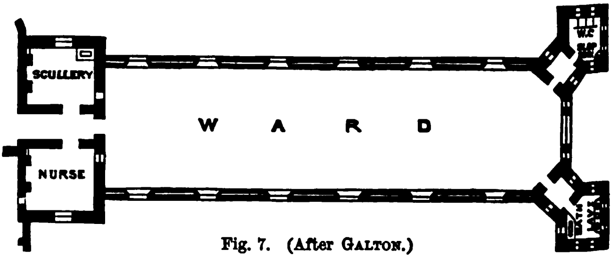

Fig. 7. (After Galton.)

The ablution-room should contain a plunge-bath with hot and cold water laid on, a shower-bath overhanging the broad end of the plunge-bath, and a lavatory table fitted with basins, and also supplied with hot and cold water. There should likewise be room enough to contain a portable bath on wheels, a hip-bath, and a foot-bath for the use of patients more or less bed-ridden. The pipes leading from the sink and lavatory table should not be boxed in, because the spaces thus enclosed become receptacles *for dirt.*

The supply of water should be ample, and the drainge and sewerage perfect. All closet pipes should be entilated and placed against outside walls. The various ttings should be of a light colour, to show dirt, and thus nsure thorough cleanliness. The walls of closets and olution-rooms should be lined with Parian cement, glazed les, or enamelled slate.

With regard to the materials of ward construction, it now strongly recommended that floors should be made hard wood, such as oak, laid on concrete and well inted; that the walls should be lined with Parian ment, or well plastered, periodically cleaned, and whiteashed or painted; and that the ceilings should be plasred and whitewashed, or painted a light colour. Floors f upper wards ought to be non-conductive of sound.

A ward thus constructed and arranged is in itself a mall hospital, and the aggregation of ward units will epend on the number of patients to be accommodated.

In an average-sized hospital the administrative buildngs occupy considerable space, and may be variously disributed. All of them, however, must be made entirely ubservient to the requirements of the sick, and should ot interfere with the ventilation of the wards. Usually he administrative buildings are as follows:—

Kitchen, provision-stores, and stores for bedding and inen. These should be central.

Apartments for house-surgeon, matron, and servants; onsulting-room, waiting-room, surgery, drug-store, and perating-room; all of them more or less central.

Laundry, mortuary, *post-mortem* room, disinfecting-oom. These should all be detached from the building.

The night-nurses should have well-ventilated bedoms at a distance from the wards, with all the necessary ppliances for ablution, etc.

The staircases for patients should be broad and easy, and should be cut off from the connecting corridors by swing-doors. The corridors themselves should be as low as possible, well lighted, warmed, and ventilated.

According to Captain Galton, the administrative buildings take up about half the cubic space of the whole hospital. As very good examples of the pavilion form of hospital on the small scale, he instances the Royal Hants County Hospital at Winchester, the Buckinghamshire County Hospital at Aylesbury, and the New Hospital at Swansea.

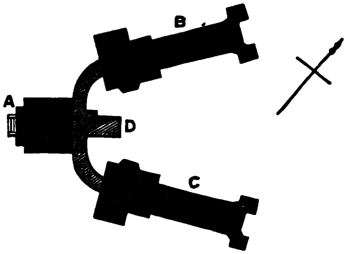

Fig. 8.—GENERAL PLAN OF SWANSEA NEW HOSPITAL.
A, Administration; B, Men's Wards; C, Women's Wards and Out-patients; D, Operating Room and Eye Ward. (After GALTON.)

With regard to the cost of pavilion hospitals, Captain Galton is of opinion that, with care and attention to economy in the design, a hospital for in-patients only, and built on a favourable site, should not cost more than from £90 to £120 per bed. The Leeds Hospital, which accommodates 350 patients, cost £197 per bed; the Royal Hants Hospital, with 108 beds, and including accommodation for out-patients, cost £229; and the Swansea Hospital, also including an outside-patient department, cost £142 per bed.

Day-wards, exercising grounds, and flower or winter gardens, are great additions to the sanitary advantages supplied by a well-constructed hospital. In summer, all the patients who are able to move about, and, indeed, most of those who are bed-ridden, should be allowed to remain during some part of every warm day in the open air. The flat roofs of the corridors, protected by awnings, would be utilised for the bed-ridden patients of the upper wards, while the corridors themselves might be appropriated by the same class of patients belonging to the lower wards. With very little extra expense the corridors ould be converted into winter gardens during the colder months of the year, and might be occupied by patients n the day-time without interfering with any of the administrative arrangements.

Recurrent outbreaks of erysipelas, pyæmia, or puerperal fever in some of the older hospitals have led many o believe that wooden huts would be preferable to even well-built pavilion hospitals. Indeed, Dr. Day of Geelong, Australia, maintains that, apart from the greater facilities for ventilation which such hospital huts would afford, the wood itself has a chemical and disinfectant property which renders innocuous the offensive products of organic matter, and destroys zymotic germs. According to his experiments, certain kinds of wood, such as red or yellow deal, American pine, and white deal or spruce, possess the property of converting "atmospheric oxygen into peroxide f hydrogen," a substance remarkable for its antiseptic ualities. Whether this view is correct or not, it is worthy of note that the Leipsic Hospital, which has been ebuilt within the last few years, consists of fourteen of hese wooden sheds or huts, and that pyæmia following upon surgical operations is seldom or never seen, whereas ormerly it used to be very common. I cannot help hinking, however, that this changed state of things is to be attributed in far greater measure to the great improvement which has taken place in the general sanitary arrangements than to any special antiseptic properties which the wood may possess. It is quite true that pyæmia or erysipelas is very often spread by carelessness, overcrowding, or neglect of cleanliness; but from instances which have come under my own observation, I believe it is not unfrequently traceable to defects connected with the drainage, which permit the influx of sewer gases into the wards. This view is confirmed by a very exhaustive report presented by Mr. Netten Radcliffe to the Local Government Board in 1876, on the sanitary condition of the Royal Infirmary, Manchester, in which he clearly proved that the prevalence of erysipelas and pyæmia in the surgical wards was due to the utterly defective state of the drainage of the building.

SECTION II.—COTTAGE HOSPITALS.

The cottage hospital system, originated by Mr. Napper of Cranleigh, is based on the principles of providing hospital accommodation for the sick poor of rural districts, with as much of the surroundings of home as possible; of permitting equality of privilege to subscribers in recommending patients, the patients themselves paying a certain sum weekly, according to their means; and of allowing any medical man practising in the district the use of the hospital for deserving cases under his care. The model cottage hospital should not have more than six beds, and must be under the management of one medical man as director, the other medical men in the district holding office as honorary medical officers. The annual cost of the establishment is defrayed chiefly by voluntary contributions and partly by the weekly payments of the patients. These weekly payments, as already stated, are regulated by the means of the patient, and vary from 2s. 6d. when the Union has to help, to 5s. or 8s. when the patient has been earning fair wages, or belongs to a *club*. All fees allowed by the Union for accidents or perations are paid to the Union medical officer, in the ame way as if he had attended the patient at his own ome. Every subscriber, no matter what the amount of is subscription, should have equal privileges in recom- ending cases, and will generally be able to state what mount the patient whom he recommends can afford to ntribute weekly. Cases of accident and emergency are mitted without order, but otherwise a recommendation om a subscriber must be procured, and this should in all stances be accompanied by a certificate from one of the edical staff, to the effect that the case is one deserving nd fit for admission. Only those are admitted who can- ot be efficiently treated at their own homes, while cases f infectious or incurable disease are excluded.

Experience has proved that in rural districts a cottage ospital of six beds will suffice for a population of 6000. he initial outlay will of course depend on whether a ottage which has already been built can be procured, nd, if so, what alterations will be necessary to convert it nto a hospital. If the hospital has to be built, the amount equired may be estimated at £600, or about £100 per ed. In converting a cottage which has already been ccupied into a hospital, the walls should be thoroughly leaned, scraped, and afterwards re-plastered and washed ith caustic lime. Attention must also be paid to the nitary surroundings of the building.

The cost of furnishing a cottage hospital for six beds ill amount to about £100, and the necessary surgical struments to about £50. The maintenance per patient eekly would cost from 10s. to 15s., so that the hospital, hen once started and properly furnished, will require for s support an annual income of at least £150, about £25 r £30 of which will be subscribed by patients.

Although the architectural arrangements may admit f many variations, the plan best suited for a cottage hospital of six beds should provide for a nurse's room, a three-bedded male ward, a two-bedded female ward, a single-bedded ward, which can be used as an operation room, a kitchen, which may also be used as a day-ward, a scullery, and a small mortuary. All the rooms should, if possible, be on the ground floor, so that good roof ventilation and ample cubic space may be secured. Part of the roof should overhang, so as to form a sort of verandah for the use of patients. It need scarcely be added that a tasteful arrangement of flowers and shrubs in the space immediately surrounding the hospital will add greatly to its cheerfulness.

The nursing, cooking, and cleaning, can generally be efficiently attended to by one woman. As the duties are therefore of a somewhat more arduous nature than those of a nurse in a general hospital, they cannot be discharged by lady-nurses or sisters. Indeed, it is found that a homely woman from the neighbourhood, trained at the hospital or elsewhere, gets on much better with the patients than the professed trained nurse. She should be able to read and write well, and must be steady, honest, attentive, and cleanly.

If a cesspool is used for the receptacle of excreta, it should be at a safe distance from the building, and constructed as described in the Chapter on Dwellings; but where no water is laid on, the pail or dry-earth system is to be preferred.—(See *Handy Book of Cottage Hospitals*, by Dr. Swete).

SECTION III.—HOSPITALS FOR CASES OF INFECTIOUS DISEASE.

By the 131st clause of the Public Health Act, 1875, power is given to the sanitary authorities of any town or district to provide, for the use of the inhabitants, "hospitals or temporary places for the reception of the sick;" and when such provision has been made, any Justice may order the removal to the hospital of any person suffering from a dangerous infectious disease who is without proper lodging, or lodged in a room containing more than one family, or is on board ship. Judging from my own experience, however, and that of other health officers, it is very seldom that a magistrate's order is required for the removal of a patient, inasmuch as patients and their friends are, as a rule, only too glad to avail themselves of the advantages of a hospital of the kind, when proper isolation and adequate nursing cannot be procured at their own homes.

In a Memorandum of the Privy Council printed in the Appendix to the First Report of the Local Government Board, it is recommended, as a condition of the first importance, that the accommodation for isolating cases of infectious disease shall be ready beforehand, and further, that it shall be sufficient for the treatment of different infectious diseases separately. The amount of accommodation required will of course vary for different places. As regards villages, for example, it is recommended that "each village ought to have the means of accommodating instantly, or at a few hours' notice, say four cases of infectious disease, in at least two separate rooms, without requiring their removal to a distance. A decent four-room or six-room cottage, at the disposal of the authority, would answer the purpose. Or permanent arrangement might be made beforehand with trustworthy cottage-holders not having children, to receive and nurse, in case of need, patients requiring such accommodation. Two small adjacent villages (if under the same sanitary authority) might often be regarded as one."

If further accommodation be at any time required, neighbouring cottages should be hired, or tents or huts may be erected on adjacent ground.

Practically, however, it is found that Sanitary Authorities are generally so averse to providing any accommodation of the kind, unless under the stern pressure of an epidemic, that, in rural districts especially, the health officer may consider himself fortunate if he succeeds in obtaining a place sufficiently central to meet the requirements of a whole union, or at least the most populous parts of it. With a good ambulance, patients, if fit to be moved at all, can, I believe, be moved a distance of about six miles without risk. In very sparsely populated districts, again, hospital accommodation is not required, because sufficient isolation can be secured by adopting a system of quarantine, and supplying skilled nursing.

For towns of any importance it is further recommended that the hospital provision should consist of a permanent building containing at least four wards in two separated pairs, each pair to receive patients of both sexes suffering from one contagious disease. The building should be larger than the average necessities of the place require, so that temporary extensions may be wanted less frequently when infectious disease has become epidemic. In case, however, such temporary extensions should be required at any time, the administrative offices ought to be made somewhat in excess of the wants of the permanent wards, and sufficient free space should be reserved around the building.

It need hardly be said that the greatest difficulty is frequently experienced in obtaining a site. Vested interests at once take alarm because the popular prejudice against living in the vicinity of such hospitals is so great that property will, for the time being, depreciate in value. The site, therefore, which may be ultimately fixed upon may not be free from objection, but it should always be such that no serious sanitary objection can be raised against it. It should be sufficiently central as regards the distribution of the population of the district, sufficiently accessible from all parts of the district, and, if possible, sufficiently isolated. There ought to be no difficulty in obtaining an abundant supply of good water, nor any difficulty in getting safely rid of the excremental matters and slops. If the soil is stiff and clayey, special care ought to be taken by means of drainage, a free use of concrete or asphalt, and abundant ventilation, to secure perfect dryness of the building.

The minimum floor-space recommended is 144 square feet, and the minimum cubic space 2000 feet. The arrangements for ventilation, heating, removal of excreta, disinfection, and the maintenance of the strictest cleanliness, ought to be of the most approved description.

The question here arises, and it is a somewhat difficult one to answer, What should be the ratio of beds to the population for whose wants the hospital is to be provided? Dr. Buchanan, in a very able address delivered in 1876 to the Medical Society of London, lays down the ratio of one bed to every 1000 inhabitants, and no doubt, taking this as an average estimate, it may be considered as fairly accurate. But much will depend upon the special circumstances of the district and population. For example, a poor crowded district will require a larger amount of accommodation than a district not crowded, and whose inhabitants are on the whole well off. In the latter case, the ratio of one bed to every 2000 inhabitants, with means for temporary extension, if it should be required, might be considered sufficient.

Temporary extension of the accommodation may be provided in the summer and autumn by tents, and in the winter and spring by wooden huts. The tents recommended are, the regulation bell-tent of the War Department, 513 cubic feet space, and the regulation hospital marquee of 3000 cubic feet space. The former should not contain more than one patient, nor the latter more than three. The ground on which they are pitched should be kept dry by means of trenches around and between them; the floors should be boarded; the approaches paved or boarded; and the tents themselves should be everywhere distant from each other at least a diameter and a half. All slops and refuse matter should be carefully removed.

With regard to huts, "dryness of site is, as in the case of tents, of the first importance. Each hut should be trenched round. Its floor should be raised a foot or a foot and a half from the earth, so as to permit the free under-passage of air; but care must be taken to prevent the lodgment of moisture or impurities beneath the floor. A distance not less than three times the height of a hut should intervene between any two huts, and each hut should be so placed as not to interfere with free circulation of air round other huts. In huts, as in permanent buildings for the treatment of infectious diseases, not less than 2000 feet cubic space, with 144 square feet of floor, should be given to each patient. The ventilation of huts, also, is of equal importance with that of permanent hospital buildings. It is best secured by the combination of side-windows with roof-opening, the latter protected from rain, and running the whole length of the ridge of the roof. The windows, capable of being open top and bottom, should not be fewer than one to each pair of beds, or in large huts one to each bed, nor should be of less size than the sash-window in common use for houses. The ventilating opening beneath the *ridge* may have flaps, movable from within the tent by pes and pulleys, so that the opening to windward can be sed, if necessary, in high winds. Double-walled wood ts may have additional ventilation by the admission of beneath this outer and inner wall, and its passage into e interior of the hut through openings with movable vers at the top of the inner lining. The roof should covered with waterproof felt; the edges of the felt stened down by strips of wood, not by nails. The hut ould be warmed by open fire-places, fixed in brick-stove cks placed in the centre of the floor, the flue being rried through the roof."

In places where no sewerage-system exists, the creta may be removed by the pail or dry-earth system, t in either case disinfectants should be used, and tside doors or flaps should be provided in the closet-locks to permit the removal of the excreta directly om the closets and not through the wards.

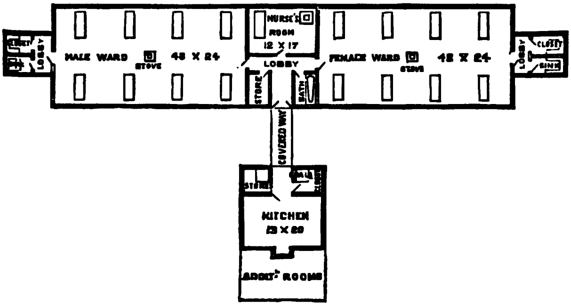

Fig. 9.

The above is a ground-plan of a hospital hut for eight patients of each sex, having the same infectious disease.

Fig. 10 is a ground-plan of an extension of hut hospitals for ten patients of each sex, having the same infectious disease, where plenty of ground is available.

Both these plans are copied from the Mem of the Medical Department of the Local Go Board already referred to.

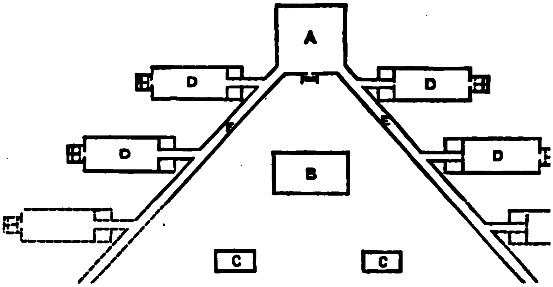

Fig. 10.

Fig. 10.—A, Administrative Buildings (Kitchen, Stores, Offices, Nurse etc.); B, Laundry, etc.; C, Disinfection, Dead-house, etc.; D, Huts fo each, with Scullery and Bath-room at end, and Closet and Sink at other E, Open Corridors. The dotted lines show direction of further extension.

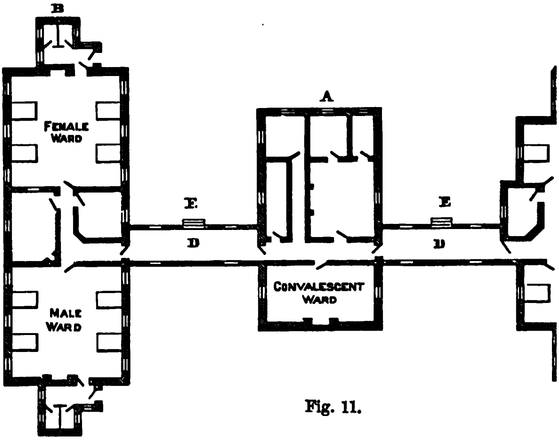

Fig. 11.

Fig. 11 is the ground-plan of a hospital w built in the Solihull Union, which forms part of Warwickshire sanitary district, in 1876. The principles of the plan are those laid down in t Government Board Memorandum, although th

re modified to suit local circumstances. The central
ck A contains a convalescent room, kitchen, larder,
all surgery, etc. There is a doorway, E, in each corri-
, D, so that the patients in the blocks B and C can
kept completely apart if required. In addition to
se blocks there are out-buildings containing a porter's
ge, a disinfecting chamber, a dead-house, a wash-house
laundry, and a shed for an ambulance. The popula-
of the Union is about 20,000; the site covers two
es of ground, and cost £400; and the estimate of the
ole of the buildings was a little over £2000.

The following very interesting particulars which
e been collected by Dr. Bland, medical officer of
lth for Macclesfield, with the view of aiding the
itary authority of that town in considering the ques-
n of hospital accommodation, may be fitly quoted here.
ey are extracted from *Public Health*, Aug. 4, 1876 :—
n Rugby they had an institution with 32 beds; the
t of building was £2069; the furnishing £380; and
average cost per bed per year, £76 : 10 : 7½. At
asgow there were three hospitals, two of which had
en in use some time, and one was in course of erection.
one of the hospitals the cost was £60 per bed, and in
other £50. At Leek the figure was very low, but
at was perhaps accounted for by the fact that the
ucture was of wood, and it was not likely that there
uld be such a one at Macclesfield. There they had
beds, the building cost £404, and the average cost
r bed was £18 : 17s.; Darlington—population 35,000,
beds, cost of building £10,622; cost per bed,
41 : 8 : 4; that was an immense sum. Tunbridge
ells—population 19,000, cost of building £400, cost
r bed £61 : 17 : 6; Nottingham—population 92,000,
beds, cost of building £2931, furnishing £708, cost
bed £40 : 9 : 9; Everton (Liverpool)—population

493,000, cost of building £13,717, cost per bed £139; Bradford—population 168,000, cost of building, including furniture £22,000, cost per bed £34:9:4; Sunderland—population 100,000, 40 beds, cost of building £2000, cost per bed £30; Hastings—population 30,000, cost of building £1000, furnishing £300, cost per bed £92 : 17s.; Coventry—population 37,617, 16 beds, cost of building £550, furniture £100, average cost per bed £40 : 12 : 6; that was an iron building. Bristol—population 195,000, cost of building £1000, furniture £200, 40 beds, cost per bed £30, four nurses; here, however, the hospital had been built on corporation land, so that the site had not been paid for."

With regard to the Rugby Hospital, I may remark that the large number of beds was recommended because the hospital was built after a violent outbreak of small-pox had taken place; while the excessive cost was caused by the fact that other works had to be stopped to obtain a full complement of men to hurry on the erection of the building, that all the time the weather was very wet and stormy, and that the men had to work during the night as well as during the day. The building was erected in a fortnight, and though the proportion of beds was as 1 to about 300 inhabitants, every bed was occupied within a few days. No difficulty was experienced in inducing every patient, no matter what his circumstances in life, to enter the hospital if fit to be removed. As a consequence the epidemic was immediately checked and kept under control, and in a comparatively short time was stamped out altogether. The Local Board defrayed all cost of maintenance, not only because it had the power to do so, but because it acted on the principle that isolation of a patient in a hospital in reality confers more good upon the public than in most cases it does upon the patient. On the other hand, the experience of the Rugby Board lso demonstrates the fact very clearly that it is a wise conomy to be prepared beforehand. If the building of the ospital had not been delayed until the epidemic broke ut, a quarter of the number of beds would have sufficed, nd the cost would have been proportionately less.

As an apposite illustration of the value of this ady-made provision for infectious cases, I may quote r. Buchanan's remarks concerning the small-pox hospital Cheltenham, from the address already referred to:— Here fourteen beds are permanently provided for small- x cases in an admirable little hospital that is devised suit the wants of well-to-do people, as well as those ho may be sent to it by the public authorities. In six onths of last year small-pox was brought into Chelten- m no less than six times, from Gloucester, from Bir- ingham, from Liverpool, and elsewhere. Seven persons of the imported disease were taken without delay to e Delaney Hospital, and except one individual, who as also removed to the hospital, nobody in the town ught the disease from these centres of contagion. There as literally no other small-pox in the town. How much ere would have been if, in the absence of the hospital, e seven importations had been allowed to spread their ntagion in a widening circle round each, can of course ly be a matter of surmise."

The management of a small infectious hospital would very much like that already described as suitable for cottage hospital. A medical officer should be appointed ho would have full powers as superintendent, but any tient should have the option of being placed under the re of his own medical attendant should he desire it. skilled nurse can always be obtained on the shortest otice from any of the excellent nursing institutions vertised in the *Lancet* and elsewhere. At times when e hospital is not occupied, the building and bedding should be kept clean and well aired. (For Rules of Management, see Appendix.)

An indispensable adjunct to a hospital is a well-constructed ambulance. In the Appendix will be found the official instructions with regard to ambulances generally, but a few hints introduced here may likewise prove serviceable. A one-horse omnibus with door behind and easy springs can be converted into a very comfortable ambulance by taking out all the lining and polishing or varnishing the wood work. The space beneath the driver's feet should be utilised in extending the internal space, and this should receive the foot-end of the stretcher. The stretcher should be made of wire or wicker work, and the handles should be jointed, so that when the stretcher is placed in the ambulance the handles will not encumbe any of the space. Instead of a stretcher, a net hammock slung on hooks will be found to be a very comfortabl mode of conveying children and young persons; indeed for that matter, there ought to be no difficulty in slinging the stretcher itself by means of strong indiarubbe bands attached to properly fixed hooks or bars. Such an arrangement would remove much of the discomfor arising from jolting, which good springs do not alway prevent, and it would cost little either in ingenuity or a regards expense to carry it out. In addition to th stretcher or hammock, there should be a hinged sea near the door for the attendant, and one or two ho water cans to secure sufficient warmth in cold weathe and during a long drive. After being used, the ambulance should be thoroughly disinfected by being washe with a strong solution of chloralum, or any other disinfectant which does not leave a disagreeable smell afterwards. The comfort of the patient would be greatl increased if, in addition to good springs, the ambulanc were provided with noiseless wheels having indiarubbe es. Particulars with regard to a disinfecting chamber ll be given in Chap. XIV.

When an infectious hospital is required at very rt notice, it may be run up of wood or corrugated n; or, to meet sudden emergencies, it has been sugted that "flying hospitals," consisting of two or more ge vans, which could be moved by road or rail, would found to be of immense service, and they could no bt be so arranged as to be made quite as comfortable hut hospitals.

At seaport towns it is proposed to use hospital-ships the "Dreadnought" type, but any hull of an old vescapable of floating and large enough, would suffice. oden huts erected on the upper deck would supply ward accommodation, while the body of the vessel ld be utilised for the administrative department. Such pital-ships would prove of immense value in the event holera again visiting this country.

CHAPTER XI.

REMOVAL OF SEWAGE.

THE term sewage may be conveniently used as indicating the excrementitious matter thrown off by the bowels and kidneys, and, indirectly, the refuse, whether solid or liquid, which is constantly accumulating in inhabited places, and requires to be constantly removed if cleanliness and health are to be maintained. A consideration of this subject will therefore have reference not only to the different methods of excretal removal, but also to scavenging.

Although in thinly populated districts it might be inferred that the disposal of the excreta and house-refuse ought to be attended with very little risk, it is found practically that, owing sometimes to nearness to the house, or at other times to being close to the well, the midden or cesspool frequently becomes the cause of severe illness, and if the contents are allowed to accumulate, is always a source of real danger. Even when a house stands widely apart from every other, the occupier cannot safely neglect the sanitary obligation which rests upon him of disposing of his house refuse, whether solid or liquid, so that there shall be no foul smells to taint the air, nor foul leakage from drains or cesspools to pollute his drinking water or render unhealthy the walls and foundations of his dwelling. And in proportion as houses are gathered together in towns or large villages, it need hardly be said that this sanitary obligation becomes more and more important. Yet nothing is more clearly established in the numerous reports of the Medical Inspectors of the Local Government Board and in published reports of health officers from all parts of the country, than the gross and utter neglect which still prevails with regard to that continuous and systematic removal of all filth which can alone ensure even an approach to cleanliness.

In the words of Mr. Simon—"There are houses, there are groups of houses, there are whole villages, there are considerable sections of towns, there are even entire and not small towns, where general slovenliness in everything which relates to the removal of refuse matter, slovenliness which in very many cases amounts to utter bestiality of neglect, is the local habit; where within, or just outside ach house, or in spaces common to many houses, lies for n indefinite time, undergoing fœtid decomposition, more r less of the putrefiable refuse which house-life, and some orts of trade-life, produce; excrement of man and brute, nd garbage of all sorts, and ponded slop-waters, someimes lying bare on the common surface; sometimes unntentionally stored out of sight and recollection in drains r sewers which cannot carry them away; sometimes held n receptacles specially provided to favour accumulation, s privy-pits, and other cesspools for excrement and slopwater, and so-called dust-bins receiving kitchen refuse nd other filth. And with this state of things, be it on arge or on small scale, two chief sorts of danger to life rise; one, that volatile effluvia from the refuse pollute he surrounding air and everything which it contains; he other, that the liquid parts of the refuse pass by oakage or leakage into the surrounding soil, to mingle here of course in whatever water the soil yields, and in certain cases thus to occasion the deadliest pollution of wells and springs. To a really immense extent, to an extent, indeed, which persons unpractised in sanitary inspection could scarcely find themselves able to imagine, dangers of these two sorts are prevailing throughout the length and breadth of this country, not only in their slighter degrees, but in degrees which are gross and scandalous, and very often, I repeat, truly bestial. And I state all this in unequivocal language, because I feel that, if the new sanitary organisation of the country is to fulfil its purpose, the administrators, local and central, must begin by fully recognising the real state of the case, and with consciousness that in many instances they will have to introduce for the first time, as into savage life, the rudiments of sanitary civilisation."

"A second point which equally with the above needs to be recognised by all who are responsible for the prevention of filth-diseases, is—that filth does not only infect where it stands, but can transmit its infective power afar by certain appropriate channels of conveyance; that, for instance, houses which have unguarded drainage communication with cesspools or sewers may receive through such communication the same filth-infections as if excrement stood rotting within their walls; and that public or private water-reservoirs or water-conduits, giving accidental admission to filth, will carry the infection of the filth whithersoever their outflow reaches. Thus it has again and again happened that an individual house, with every apparent cleanliness and luxury, has received the contagium of enteric fever through some one unguarded drain inlet; or that numbers of such houses have simultaneously received the infection, as an epidemic, in places where the drain inlets in general have been subject to undue air-pressure from within the sewer. And thus equally on the other hand it has again and again happened that households, while themselves without sanitary reproach, have received the contagium of enteric fever through some nastiness affecting (perhaps at a considerable distance) the common water-supply of the district in which they are."—(See Mr. Simon's *Reports*, New Series, No. II.)

In describing briefly the various methods of sewage-disposal, it will be convenient to discuss the subject under the following sections:—

1. The water system.
2. The privy or midden system.
3. The pail system.
4. The dry system.
5. Lieurnur's, and other continental systems.
6. Systems best suited for rural districts.
7. Disposal of slops.
8. Public scavenging.

With regard to systems other than the water-carriage system, most of the information here collated has been obtained from the valuable joint-report of Dr. Buchanan and Mr. Netten Radcliffe (see Mr. Simon's twelfth *Report* to the Privy Council), and from the still more elaborate report of Mr. Netten Radcliffe, contained in No. II. of the New Series already referred to, as well as from the report on sewage disposal issued by the Local Government Board in 1876.

SECTION I.—THE WATER SYSTEM.

Where there is no unusual difficulty in dealing with the sewage at the outfall, there can be no doubt that the water-carriage system of sewage removal is the one best suited for large towns. In the great majority of towns, however, this difficulty has become so very serious, or the drainage in parts is so defective, that the water system has been supplemented by other plans varying according to local requirements, but all of them intended to deal more particularly with fæcal matters. Apart from considerations of cleanliness and convenience, this system possesses the additional advantage of employing the same channels for the removal of sewage which are required for the removal of waste water, and not only so, but the waste water can in this way be utilised as a very efficient vehicle for the conveyance of the excreta. In most cases the subsoil water, surface water, and the water used for domestic purposes, are all eventually discharged by the same channels, so that the drainage and sewerage of a town usually form part of the same system.

1. *Drains and Sewers.*—In any system of drainage intended to carry off surface water and drain the subsoil, it is necessary that the drainage channels should have sufficient area and declivity to maintain the discharge of the water which they receive at all times, and at its fullest flow. This quantity will of course depend chiefly on the rainfall of the locality to be drained, and upon the amount entering the drains from other sources. Thus, in country districts, the water to be carried off may be partly derived from porous strata, which have their gathering ground beyond the boundary ridges of the drainage-area; and in towns, the water-supply artificially brought in is added to the amount derived from the drainage of the inhabited district. Moreover, as the soil acts as a kind of reservoir, the water does not enter the drains in the open country as rapidly as it falls, indeed a considerable portion of it is evaporated or absorbed by vegetation; but in towns it runs off the roofs and paved or macadamised surfaces almost as fast as it is delivered.

Guided by these considerations, engineers have estimated that the capacity and declivity of the water-channels for country districts should be sufficient to carry off the greatest available rainfall occurring during *twenty*-four hours in that space of time, whereas in towns hey should be capable of discharging the greatest hourly ainfall on the area, and the greatest hourly supply from ther sources. The depth of the greatest hourly rainfall estimated by different authorities at from half an inch an inch.

In small towns, where the storm-water, or greatest urly rainfall, may be passed over the surface without using injury, the main sewers need not be constructed a capacity to discharge it,—a plan which has been rried out at Penzance and Carlisle. In other towns ain—as at Dover, Ely, Rugby, etc.—most of the storm-ater is carried off by the old drain-sewers, and the wage by separate pipe-sewers; or pipe-sewers are used clusively for the sewage, and separate brick drains are nstructed for the subsoil and storm-waters.

The advantages of the pipe-sewer system are, that e pipes, if strong and well jointed, prevent percolation; at they can be quickly laid, and require much less cavation than brick sewers; that they can be made of rious curves to suit different positions; and that, with proper declivity, they are not liable to get fouled. nother great advantage depends on the fact that the wage can be treated without excessive dilution, and hen a pumping-station is required at the outfall, the iginal cost and working expenses are much lessened. the other hand, the pipe system does not fully ensure e important hygienic condition of drying the subsoil if parate drains are not laid down, or unless subsoil pipes conjoined with sewer pipes, as in the system devised Messrs. Brooke and Son of Huddersfield. Drain wers, however, as they are usually constructed, do act iciently as subsoil drains, but at the same time it must t be forgotten that all such sewers are more or less aky, and are therefore a constant source of danger to y wells or water-mains which may be near them.

(1.) *Construction of Drain-Sewers.*—The main drains or sewers of a town are underground arched conduits, built of brick in cement, and should be perfectly water-tight. They are generally laid on a bed of concrete, to prevent sinking of any part of the track, and consequent fracture. The cross-section preferred for them is an egg-shaped oval, with the small end downwards, and with a width of at least 2 feet, to allow men to enter them for the purpose of cleansing and repair. They should be laid out in straight lines and true gradients from point to point, so that the current shall have a velocity of not less than 1 foot, and not more than 4½ feet, per second. At each principal change of line or gradient, arrangements should be made for inspection, flushing, and ventilation and at all junctions or curves the declivity should be increased, to compensate for friction. No sewers or drains should join at right angles, or directly opposite the entrance of others. Tributary sewers should deliver in the direction of the main flow, and should also have a fall into the main at least equal to the difference between thei diameters.

Surface-drains or gutters communicate with th under-ground drains by gulley-holes, which are covered with gratings, and generally fitted with syphon-traps t prevent the escape of foul air. Branch drains, leading from the houses and from the adjoining ground, ar usually made of earthenware pipes, bedded on concrete and well jointed in hydraulic mortar or cement. They should never be less than 4 inches in diameter, an should have a declivity sufficient to ensure a velocity o flow of at least 4½ feet per second, to prevent the forma tion of deposits. All junctions with other drains o sewers should be curved or acute-angled, and, wheneve practicable, they should be made in a vertical or transversely inclined, instead of a nearly horizontal, plane

Pipes of small size should always be joined on to pipes of larger size, as 4-inch pipes into 6, 6 into 9, and 9 into 12.

No drain should ever commence in the basement of a house, otherwise the updraught produced by the increased inside temperature will occasionally draw the air through any trap. Cellars should be drained by making the drain so as to discharge upon a trapped grating communicating with the drain outside the wall of the house, or, if this cannot be readily effected, the drain should be trapped, and well ventilated either by a special pipe or an open grating. Where houses have to be drained from back to front through the basement, the drain-pipes should be carefully jointed, bedded in concrete, and ventilated back and front outside the walls of the house. Sink-pipes, and pipes from cisterns, lavatories, or baths, should never communicate directly with the drains, or when they do so, there should always be a trap with an opening on the other side for ventilation at each point of connection. All soil-pipes should be ventilated, and no other pipes, such as overflow-pipes from cisterns, should open into them.—(See Chapter on Dwellings.)

(2.) *Ventilation of Sewers.*—In order to prevent concentration or stagnation of the gases which are largely given off by sewage, it becomes a matter of the utmost importance to provide numerous openings communicating with the sewers, to ensure free ventilation. Main sewers, with steep gradients, should have a man-hole, a tumbling bay, and double ventilating arrangement, at intervals of not less than 300 yards. The tumbling bay or fall is provided to allow of a flap-valve being applied to the discharging end of the sewer, and thus compel the gases to ascend through the ventilating shaft. One or more charcoal baskets may be placed in the manhole to deodorise the sewer-air as it escapes, and before it enters the ventilating chamber, but charcoal should never be when it can be avoided, because it impedes free ven tion. The manhole and ventilating chamber are built by side, and together constitute the ventilating shaft.

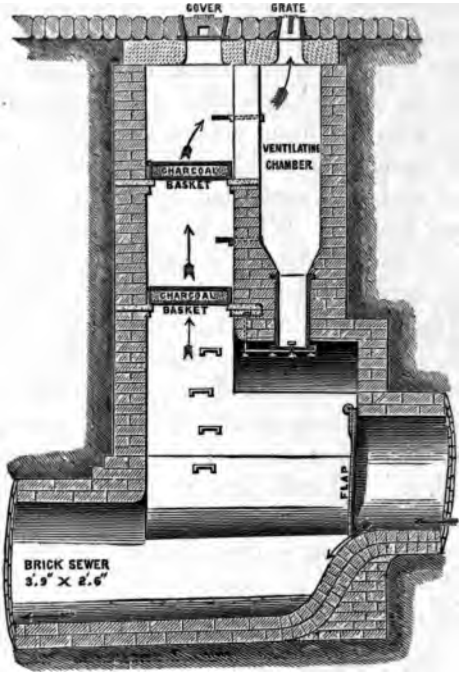

Fig. 12.—Manhole, Tumbling Bay, and Double Ventilating Arrangement. (After Rawlinson.)

For ordinary sewer-ventilation, the manhole wit a side chamber may be utilised as a ventilating shaf efficient ventilation can be secured by making a suffic number of direct openings into the crown of the se Manhole covers can also be utilised as ventilators by serting an open grating into them. In cases where sewer runs parallel with and close to the pavement, i advisable to carry the ventilating shaft in a sloping di tion to an open grating situated in the centre of the street. All these different methods of sewer-ventilation have been carried out in several places at my suggestion, and have been found to answer admirably. The mistake which is often made is to carry out extensive improvements of this description during the warm months of summer or autumn. At this period of the year the evolution of sewer-gases is greatest, and as it is evident that it must take some considerable time to construct a large number of ventilating shafts, great complaints are made of the foul effluvia which are discharged through the openings which are first made. All such improvements, therefore, should be carried out during the colder months of the year, when the sewers are better flushed and sewer-gases are not generated so rapidly.

With regard to the number of openings, it may be said generally that the terminals of all drains and sewers should be ventilated, and the junctions of branch sewers with main sewers. According to Mr. Rawlinson there should be not less than 18 fixed openings for ventilation, or 1 at intervals not greater than 100 yards, for each mile of main sewer. Flap valves, or other contrivances, should be provided for the outlet ends of sewers, to prevent the wind from blowing in. In some cases street ulleys, if left untrapped, could be utilised as ventilators. ndeed, the great object of ventilation is by means of umerous openings to so dilute the sewer air as to render innocuous and imperceptible to the senses. Some entilators will act as inlets for fresh air, and others as utlets, according to the direction of the wind.

Main sewers, liable to be affected by the rise of tides r land floods, must be abundantly ventilated, in order hat the sewer air may not be forced back into the tributary sewers and drains. To provide for efficient ventilaion under these circumstances, Drs. Parkes and Sanderson, in their report on the sanitary condition of Liverpool, recommended the erection of lofty shafts with a sectional area at least half as great as that of the sewers. They condemned the ventilating shafts in use at the date of the inquiry as being too narrow, and ascertained by experiment that the Archimedean screw ventilators, with which the shafts were supplied, only aided the extractive power by 20 per cent.

(3.) *Flushing of Sewers.*—As offensive discharges of sewer-air are generally due to the formation of deposits, careful attention to systematic flushing is highly essential. The flushing of sewers is effected by damming back the water, and removing the obstruction when a sufficient collection is made, the sudden rush clearing away any deposit that may have taken place. In addition to the arrangements for flushing, which should be provided at every manhole, there should also be a flushing chamber at the head of each sewer and drain, such chambers being flushed either from the mains where there is a public water-supply, or from water-carts. Sewers in straight lines, and even gradients from manhole to manhole, can be cleared out by using scrubbers.

No water from manufactories of an elevated temperature should be allowed to enter sewers before being cooled, because it accelerates putrefactive changes in the sewage. Blowing off steam from boilers into them is also objectionable.

With a system of sewerage properly constructed, well ventilated, and regularly flushed, the dangers arising from atmospheric pollution by sewer-gases is reduced to a minimum. Indeed, the amount of impurities in sewer-air under these conditions is so small as to be almost inappreciable to the sense of smell, and it may be laid down as a rule that whenever foul effluvia are given off, it is an indication that the sewer is insufficiently ventilated, imperfectly flushed, or that it has been badly constructed in the first instance. In exceptional cases charcoal may be used, but it is wrong in principle, as it cannot deodorise sewer-gas without impeding the ventilation. Formerly the practice of employing it in ventilating shafts was general, but all who have practical experience in the matter are now agreed that direct open ventilation is the heapest and most effectual method, and that when properly carried out it does not give rise to nuisance. When harcoal is used, the kind best suited for the purpose is rdinary wood charcoal, broken into small pieces about he size of coffee-beans, and clean sifted. The layer in he tray or basket should never be more than 3 inches leep, otherwise the passage of the air would be almost ompletely obstructed. Charcoal always acts most effiiently when kept dry, but it does not altogether lose its leodorising powers when it becomes damp. Instead of askets, Mr. Baldwin Latham introduced some time ago system of spiral charcoal trays for the ventilation of ain sewers.

But though charcoal may thus be found to be useful abating the nuisance arising from the effluvia issuing rough an exceptionally situated ventilator, it cannot too strongly urged that the evil of a foul-smelling wer should be dealt with at its source. If a sewer is l, leaky, or otherwise so imperfect from original faulty nstruction as to be nothing but an elongated cesspool, e sooner that it is abolished the better. Unfortunately, wever, sewers of this description exist in almost every wn, and not only so, but the gravest errors have been rpetrated in laying down house-drains in total ignorance sound sanitary principles, and with the grossest caressness as regards workmanship.

(4.) *Shone's Pneumatic System.*—Some mention ought be made here of this system, which was first brought to notice at the meeting of the Sanitary Institute of Gre Britain at Stafford in 1878, and has recently received considerable share of attention. It has been for so time on trial at Wrexham, and there can be little do that it will assist engineers in overcoming many of t difficulties with which they have hitherto had to conten more especially in low-lying and undulating districts By means of *sewage ejectors,* which are worked by compressed air conveyed in pipes from a central station, where the engine-power may be either steam or water, Mr. Shone proposes to force the sewage along properly-constructed pipes, or sealed sewers, as he calls them, to the outlet, or over rising ground. The ordinary gravitating sewers, properly ventilated, and kept properly flushed, are made to discharge into one or more collecting stations according to the size and contour of the town; and in these stations are placed the ejectors. So soon as the sewage is forced into the sealed mains from the ejectors, all communication, both with the street and house-sewers, as well as with the atmosphere of the town, is completely severed, and the sewage is harmlessly and rapidly hurried on to the outlet. Flat stagnant sewers and deep cuttings may thus be avoided, and pumping in many instances may be dispensed with. The system is intended to promote health and economy, and is applicable to mansions and large public buildings as well as to towns.

2. *Traps.*—That too much reliance has been placed by engineers and builders on the efficacy of traps for the exclusion of sewer-air, is becoming every day more and more evident. Up till quite recently no adequate provision was made for drain or sewer ventilation, and the consequence was that mechanical ingenuity became taxed to the uttermost to prevent the pent-up sewer-gases from forcing their way through the terminals of drains whic for the most part were situated inside houses. When ho

water is poured down a drain, or when a sewer becomes suddenly charged with a large volume of water, as after a heavy fall of rain, the forces which are brought to bear within the sewer are far greater than the resisting power of any trap, and the displaced gases make their escape often at points where they are the most dangerous. There are few traps whose resisting power exceeds that of a column of water an inch and a half in height; indeed, the greater number of them, as for example common bell-traps, have only a resisting power of about one-quarter of an inch. Besides, it should be remembered that the water in an otherwise very efficient trap will absorb sewer-gas on one side and discharge it but little changed on the other. All traps, therefore, should be regarded as at the best useful auxiliaries only, for in no case will they afford protection against the escape of foul air if proper ventilation be neglected. Some traps, such as the common bell-trap, are worse than useless, because they are readily removed, often forgotten to be replaced, and are easily broken. Many traps, too, and especially those which are supposed to protect the terminals of drains in cellars or basements, are practically useless, because the water in them speedily evaporates, and is seldom renewed.

Although there is almost an infinite variety of traps, the most useful of them are either of what is called the mid-feather description, or are constructed on the syphon principle. Flap-traps are sometimes used for sewers or large drains, but they are merely hinged valves which permit water to flow in one direction only, and are also intended to prevent the reflux of sewer-air. In the ball-trap, a floating ball is lifted up when the water rises, and when it reaches a certain level the ball impinges on and closes an orifice.

All traps constructed on the mid-feather principle have one or more partitions dipping down into the water between the entrance and discharge pipe, and as water stands in the trap to the height of the discharge pipe, the partition is always under water. What are called D-traps are of this description, and the common bell-trap, with its various modifications, belongs to the same category. The following are illustrations of useful traps of the mid-feather variety.

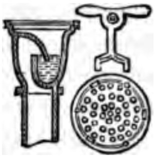

Fig. 13.—Antill Trap and Lock Grate.

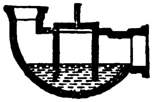

Fig. 14.—Cottam's Effluvium Trap.

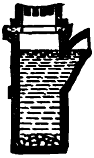

Fig. 15.—Simple Gulley Trap.

The Antill trap makes a very good sink trap, but if the sink-pipe is made to discharge on to an open grating outside, almost any article-intercepting trap will suffice. Syphon traps may be described as curved tubes, in which the whole of the curve should be always full of water. All bath and lavatory pipes should be trapped in this way, even when they do discharge on to outside gratings, to prevent the entrance of cold air. Fig. 16 is an illustration of a syphon trap ventilated in the middle.

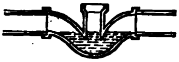

Fig. 16.

Amongst good ventilating traps well adapted for house drains, may be mentioned Mansergh's ventilating trap, manufactured by Jennings, Molesworth's trap, and the trap known as "The patent Edinburgh air-chambered sewer trap," manufactured by Messrs. Potts and Co. of Birmingham. Any one of these secures ventilation of the drain leading from the closet, and permits of disconnection of other pipes, in houses where considerable difficulty would be experienced in ventilating the soil-pipe. The plan proposed by Professor Reynolds of sinking a manhole to the outside drain, and of depressing the bottom of the trough so that the water shall stand half an inch above the outlet on the sewer side, and an inch above the mouth of the house-drain, secures the same object, and acts as a mid-feather trap, while the manhole acts as a ventilator. Mr. Banner's patent house-drain trap and patent ventilating cowl for soil-pipes, and Buchan's patent ventilating drain traps may also be mentioned as very efficient and easily applied improvements. By adopting one or other of these appliances, the most serious defects connected with house-drainage may be effectually removed, provided the drains are well enough laid, in the first instance, to prevent leakage.

3. *Water-Closets.*—The situation, construction, and general arrangement of the water-closets best suited for private houses have already been described in the Chapter on Dwellings. In the crowded districts of large towns, however, the ordinary form of water-closets has proved a failure, partly on account of the complicated character of the contrivances for flushing, but chiefly on account of the carelessness and filthy habits of the poorer classes. For these reasons some special modifications of the usual plan of closet, suited for large collections of people, and whose management may be more under the control of the public authorities, have been devised and introduced into several large towns. The arrangements which have been found to answer best are the trough-closets in use at Liverpool, the tumbler-closets in use at Leeds and Birkenhead, and what is known as the "Bristol Eject" in use at Bristol.

(1.) The *Trough-closet* may be described as consisting of a series of closets communicating with a long trough situated beneath and behind the seats which receives the excreta from each closet in the series. The lower end of the trough communicates with a drain leading to the sewer by an opening which is closed by a plug. Behind the back wall of the closet there is a small space, to which no one has access but the scavenger, and from which alone the plug can be raised by means of a handle. The scavenger visits daily, empties the trough, washes it out with a hose connected with a hydrant, and again charges it with water. As much water is let in as will cover the excreta received during twenty-four hours, and so prevent any smell. The closets are kept clean by the users, and an inspector visits occasionally to see that cleanliness is maintained. Offenders may be summoned, and fined or imprisoned.

Dr. Buchanan and Mr. Radcliffe, in the report already alluded to, make the following observations with regard to the trough-closets:—"Nothing could be more admirable than the working of the Liverpool arrangement, and nothing could be more marked than the difference between them and what are called water-closets in the poor neighbourhoods of London and other large towns;" and this favourable opinion is fully confirmed by Mr. Radcliffe in his more recent report.

(2.) The *Tumbler-closet* resembles the trough-closet in its general plan and structure, but differs from it in regard to the arrangements for flushing. At the upper end of the tumbler-closet trough there is a swinging basin, into which water is constantly trickling, and which is so constructed that it capsizes whenever it becomes full. In this way the contents of the trough are every now and then washed into the drain, at longer or shorter intervals as may be deemed necessary. Although these closets are capable of doing good work, it appears from Mr. Radcliffe's report, and an admirable report written by Mr. Vacher, health officer for Birkenhead, that, owing to want of proper supervision and an insufficient supply of water, they have practically failed.

(3.) The *Bristol Eject.*—According to Mr. Radcliffe, *this* consists of a strongly constructed dip-trap interposed tween the privy trunk, as the receptacle is termed, and e drain. It thus admits of the ready extraction of reign matters which may be thrown in, it is not easily oken, and as it is flushed and kept clean by the servants the corporation, it is found to answer much better than linary water-closets among the poorer classes of large wns.

For barracks, prisons, etc., water latrines of a much npler construction than either of the above answer ex- dingly well. An open metal trough roofed in, and th the necessary partitions and doors, receives the reta, while its anterior upper margin constitutes the t. In order that the excreta may be constantly covered, trough should be kept one-third full of water. It uld also be well flushed at least twice daily, and the tents allowed to run off into a drain connected with a ver. A plug or flap-door at the lower end of the trough l be required to prevent the water from draining off ing the intervals.

There is a further advantage, common to all closets the trough system, which may here be pointed out. the event of an epidemic of cholera or enteric fever ing in the crowded courts where these closets are in , it will be an easy matter to throw disinfectants into troughs, and thus destroy the infectious power of the ine discharges.

(4.) *Intercepting Tanks.*—This system of intercepting solids and allowing the liquid part of the sewage to off into the drains, has been advocated by many, on grounds that the manure thus collected can be readily lised, that there is no risk of clogging up the sewers, d that the sewers themselves may be constructed of ich smaller dimensions. Many of the *fosses perma- ntes* and *fosses mobiles* on the Continent are constructed this principle, and in this country a tank has been introduced by Mr. Chesshire of Birmingham, which has been well spoken of by Dr. Parkes, and Dr. Hewlett, health officer of Bombay. The following is the patentee's description of the tank:—"The plan or form at present preferred is that of an iron box, large enough to hold the solid part of the excreta of an average household for from eight to twelve months, and yet, when full, within the power of two strong men to lift. This box is 2 feet 4 inches long, by 18 inches wide and 18 inches deep. The pipe from the privy or closet passes into the top of the box, by preference at the opposite corner to the outlet or waste-pipe, which, placed at the bottom of the box, is divided from the main part by a perforated grating extending across the corner and the whole height of the box. Except as to the inlet and outlet pipes, the box is hermetically sealed, though the lid can be readily removed when it is desirable to empty it. The connection of the inlet and outlet pipes to the box can also readily be separated and re-made without the assistance of the plumber."

It is doubtful, however, whether this or any other plan which merely intercepts the solids, can ever be commended for extensive use. For on the one hand, the prevention of the more solid portion of the excrement from entering the drains does not materially lighten the sewage-problem, and on the other, the detention of filth on premises, even though it be in close boxes, is wrong in principle and cannot be regarded as free from danger. Indeed, the advantage above all others which attaches to the water-closet system when efficiently carried out, is the continuous and complete removal of all excremental matters from dwellings.

(5.) *Urinals.*—These should be lined with glazed stoneware tiles, or enamelled slabs of smooth slate. They can be kept perfectly clean and inodorous by allowing a small quantity of water to trickle down them constantly.

In all towns of any size it is a great desideratum on the score of cleanliness, health, and convenience to provide public lavatories in suitable localities supplied with water-closets, urinals, and washhand basins, and they should be provided for the female as well as for the male sex. At Nottingham a ladies' lavatory has recently been provided by the Corporation, which about pays for interest on outlay and attendance, and in Glasgow three such lavatories have also lately been opened.

SECTION II.—THE PRIVY OR MIDDEN SYSTEM.

From what has already been said, it is obvious that the privy or midden system of old type, with leaky and fœtid cesspits behind, is totally inapplicable to populous places. Cesspools and large deep ashpits in connection with privies are equally objectionable, no matter what precautions be taken. To improve the system so as to render it even tolerable, it is essential that the pit should be small in order to secure frequent removal of the contents; that it should be shallow and perfectly water-tight to prevent leakage; that it should be roofed in, to keep out rain; that it should be well ventilated; that it should be easy of access; that it should be at a safe distance from the house; and that the contents should be kept dry and inoffensive by means of sifted ashes or other dry refuse. It is not necessary that it should be drained, for if the ashes do not keep the excreta dry the system is a failure. According to Mr. Netten Radcliffe, the only kinds of midden-privies which were found to answer all these requirements fairly well are the improved middensteads of Hull and Glasgow. The *Hull middenstead* consists solely of the space under the closet seat, and its floor is formed by a flag which slopes downwards to the back wall at the ground-level there. The ashes are thrown in through the hole in the seat, and the front board of the seat is movable, to enable the scavenger to get at the contents, which are removed weekly. Privies of this description can be built for about £3. The *Glasgow middenstead* is proportionately of smaller size than the Hull middenstead, but is extended sufficiently far back from the seat to admit of the ashes being thrown upon the excrement from behind. As several families use one privy, the contents are cleared away every two days.

Other schemes, intended to diminish the offensiveness of large middensteads, as observed in Manchester, Salford, Nottingham, and elsewhere, were all found to have practically failed. In Manchester, where many of them were drained into the sewers, it was discovered that the sewers were becoming gradually choked up with sediment.

SECTION III.—THE PAIL SYSTEM.

The more common varieties of this system are the following:—

1. Pails used without preparation (Glasgow).
2. Pails supplied with a deodorant and antiseptic (Rochdale, Birmingham, Nottingham, Leeds).
3. Pails lined on the Goux system (Halifax).
4. Pails in which ashes and house-refuse as well as excrement are deposited (Edinburgh, Nottingham).
5. Pails into which coal ashes are screened above the excrement (Manchester, Salford, Cockermouth).

In order to carry out this system in the most efficient manner, two pails are required for each closet one to receive the excreta, and the other the ashes and house-refuse. The excrement pail may be either a wooden pail or tub, as used at Rochdale, Nottingham and Halifax; or it may be of metal, such as that used in Manchester, Leeds, and Glasgow. In either case it i requisite that it should be round, so that it can be easily cleaned, and as regards capacity and convenience for removal, its cubic contents should not exceed 10 gallons. If of wood, it should be tarred or creosoted, and if of metal, it should be made of galvanised iron. All pails should be provided with tight-fitting lids, such as Haresceugh's excreta pail with patent spring lid, so that they can be carted away without creating nuisance. When one pail is removed, another, which has been thoroughly cleaned after having been emptied at the depôt, should be left in its stead.

The ash pail should be somewhat larger than the excrement pail, and may be either a rectangular box of handy dimensions, a tub, or a galvanised iron pail.

In the Goux system as carried out at Halifax, the tubs are lined with some dry absorbent material, such as chaff, straw, shoddy fluff, hay, dry ferns, or any kind of animal and vegetable matter which is useless for other purposes. The patentees direct that these materials are to be mixed in such proportions as may be most convenient, together with a small percentage of sulphate of iron or sulphate of lime. The materials are pressed close to the bottom and sides of the tub by means of a mould which is afterwards withdrawn. A separate bin must be used for the ashes and house-refuse; but urine may be emptied into the tub, and is supposed to be absorbed by the lining, the excreta remaining tolerably dry. The tub is removed once or twice a week, according to circumstances.

When these closets are well managed, they are clean and inoffensive, and the system generally has been favourably reported on by Mr. Haviland of Northampton, and Mr. Syson of Huntingdon, as well as by Mr. Netten Radcliffe. On the other hand, it has been asserted that the material used for packing generates swarms of minute

flies, and that in other respects the system, as it i
carried out, is not free from nuisance. Althougl
perhaps too much importance attached to the a
power of the packing material, there can be no d
the advantages of the Goux system, when compa
the midden system, cannot well be over-rated.
properly managed there is less offensiveness tl
the ordinary pail system, while the resulting n
much more easily dealt with, and, it is said, con
readier sale than ordinary pail closet manure mi
ashes. According to Mr. Haviland, who has
reported on the system, filth diseases have greatly
in Halifax since its first introduction, but this, c
is a result which should follow the substitutio
pail system for the old-fashioned privy or midde

In the Rochdale system the contents of the
are screened by machinery at the manure depôt
ashes are spread out in deep layers, and into
made in these layers the contents of the excrem
are poured as received. The excrement is then
with fine ashes, and sulphuric acid is added in
portion of 25 lbs. to 1 ton of the excrement, to
drying. The proportion of excrement to fine as
finished manure is 80 parts of the former to 3
latter. After the excrement pails have been
they are thoroughly cleansed by water delivere
hose at 40 lbs. pressure, and before being sent o
yard each tub receives a small quantity of disi
consisting of equal parts of chloride of lime a
alum mixed in ten parts of water.

According to the Report on Sewage Disp
Rochdale manure was not readily taken awa
estimated price of £1 per ton, but gradually accu
and the Committee further state that this is th
ence in all cases within their knowledge of

modes of dealing with excreta. In 1875 the
s of the manufacture became so great that the
ntents were merely mixed with the house refuse
es, but there is immense difficulty in getting rid
mixture. This plan has also been tried in Bir-
m, but the resulting manure, even though the
ave been finely sifted, is so offensive that constant
nts are received from surrounding rural districts
ich large loads of this manure are being continu-
nveyed. Whatever be the estimated value of the
, farmers obtain it at a mere nominal price.

Manchester and Salford a dry ash system of ex-
-disposal has been combined with a pail system.
places Morrell's patent self-acting cinder-sifting
ets have been extensively introduced.

to the kind of closet best suited for the pail
it is found that a closet somewhat after the im-
Hull or Glasgow pattern, but with level floor and
ace enough to contain the ash-pail as well as the
nt pail, is the cheapest and most convenient.
ng to Mr. Netten Radcliffe, “it would be difficult
gest any great improvement upon the patterns
in Rochdale, Manchester, and Halifax. The
tness of the plan and the facility with which the
set can be adapted to the varied requirements of
ns in the reconstruction of midden-closets, is most
ively shown in the plans given of adaptations in
.”

regards general results, he further states that “the
tem not only effectually does away with midden
e, but, as carried out in Rochdale and Manchester,
he only one which, while utilising profitably all
mestic refuse, appears to give promise of paying
ely for the expense of its working.”

following is a description of the method of collection and treatment :—The pails containing the excret mixed with fine ashes, and the tubs containing th coarser cinders and house refuse, are collected in specially-constructed pans divided into five compartments, one o which is open and receives the dry refuse, the other fou being covered with close-fitting doors, and each receivin six excreta pails provided with close-fitting lids. Whe the loaded vans reach the yard they are first weighed afterwards they are taken on to the first floor of a two storey building, where the dry refuse from the open pa of each van is unloaded and shovelled into sieves worke by steam power. By this arrangement the fine dust widely diffusing itself in its descent, falls on the floo below, covering the contents of the pails, which are, a the same time, being emptied on to gratings fixed in th floor. At one end the bars are set much more closel together than at the other, and serve to convey the liqui portion of the contents of the pails by means of trough to a tank, from which it is afterwards removed to a apparatus called a concretor. The solid portion of th excreta falls through the wide-barred portion of th grating into suitable receptacles. The rough portion o the dry refuse, after being separated from the fine, i carried along an endless band of wooden bars to th mortar mills, the boiler, or to one of the various furnace of which there are several in the yard. The dry refus is of such a heterogeneous character as to require varie modes of treatment. The cinders are separated and use for fuel for the boilers and furnaces (no coal whateve being allowed in the yard); the remaining portion of th rubbish is taken to the carbonisers (of which there ar eight), and the material, often of an obnoxious descriptio is therein carbonised and converted into a harmless an useful substance. In another part of the yard is a secon set of furnaces, called destructors, which are used for th purpose of destroying rubbish which formerly had been deposited in large heaps in every suburb of the city. These destructors not only consume the objectionable material, but furnish heat to the concretors, large cylinders laid horizontally, and revolving by steam power, in which the liquid of the pails (chiefly urine) is evaporated to one-tenth of its bulk, and afterwards formed into a valuable manure by being mixed with two-thirds of its weight of harcoal from the carbonisers. The spent fuel is carted o the mortar mills, and there ground up with broken arthenware and glass, fine ashes, and lime, to form a nost excellent mortar, which contains one-third of its veight of lime, and sells readily at 4s. 6d. a ton. 400 ons of manure are made weekly, and sold at 12s. 6d. er ton. The carboniser, the destructor, and the conretor, have all been invented and patented by Mr. lfred Fryer, of the firm of Manlove, Alliot, and Co., ngineers, Nottingham.

This process of purification by fire, as it is called, has lso been recently adopted by Birmingham, Leeds, Rochale, and Stafford, and the results will be watched with reat interest.

SECTION IV.—THE DRY SYSTEM.

The difference between what is called the dry system excretal removal and the pail system depends upon the odorising and destroying power of the dried earth or her material, which, if used in sufficient quantity, conrts the mixture into a uniform and inoffensive mass.

1. *Moule's Earth-closet.*—This consists of a wooden x with a receptacle or pail beneath, a reservoir for the y earth above, and an apparatus for measuring and livering the requisite quantity of earth whenever the oset is used. The closet is made self-acting by means a spring in connection with the seat, or it is worked

by a handle as in the ordinary water-closet. It is essential that the earth be previously dried and sifted, that a sufficient quantity be thrown into the pail before the closet is used, and that the same amount be delivered over each particular stool. The quantity requisite for the deodorisation of each stool (inclusive of the urine) is found to be 1½ lb. The slops and the rest of the urine must be removed in some other way.

This system has been introduced, with more or less success, into several public establishments in this country (Broadmoor Lunatic Asylum, the Manx Lunatic Asylum, Isle of Man, the Reading Workhouse, etc.), at the Wimbledon Camp, and several villages throughout the country. Its use in India has been very highly spoken of by Dr. Mouatt, late Inspector of Indian Gaols.

Dr. Buchanan, in Mr. Simon's Report for 1869, makes the following summary with regard to the working of the earth system:—

"(1.) The earth-closet, intelligently managed, furnishes a means of disposing of excrement without nuisance and apparently without detriment to health.

"(2.) In communities the earth-closet system requires to be managed by the authority of the place, and will pay at least the expenses of its management.

"(3). In the poorer classes of houses, where supervision of any closet arrangements is indispensable, the adoption of the earth system offers special advantages.

"(4.) The earth system of excrement-removal does not supersede the necessity for an independent means of removing slops, rain-water, and soil-water.

"(5.) The limits of application of the earth system in the future cannot be stated. In existing towns, favourably arranged for access to the closets, the system might be at once applied to populations of 10,000 persons.

"(6.) As compared with the water-closet, the earth system has these advantages:—It is cheaper in the original cost, it requires less repair, it is not injured by frost, it is not damaged by improper substances driven down it, and it very greatly reduces the quantity of water required by each household."

The agricultural value of the earth excrement, its facility of transport, and variety of application, are also pointed out.

The disadvantages of the system are—the difficulties of procuring, drying, and storing the earth, particularly in crowded localities; the special service and attention which the closets require; the frequent discomfort attending their use when the earth is very dry and powdery; and the inadequacy of the system as a means of removing the whole excreta and slops. "Add to these circumstances the enormous aggravation of all the difficulties of he plan, when not 50 but 50,000 households have to e provided with the necessary appliances, and induced o work them properly, and we can have no hesitation in ronouncing the dry earth system, however suitable for stitutions, villages, and camps, where personal or official gulations can be enforced, entirely unfitted to the cirumstances of large towns."—(*First Report of the Rivers' ollution Commissioners*, 1868.)

When the closets are properly managed, it appears at the fæcal matters are disintegrated, so that after a me no excrement whatever can be detected in the mixure. After keeping and drying, therefore, it may be used veral times without losing its deodorising and absorbing roperties, but much depends on the quality of the earth ed at the outset. The suitability of various soils are ven in the following order:—1, rich garden mould; , peaty soils; 3, black cotton soils; 4, clays; 5, stiff ayey loams; 6, red ferruginous loams; 7, sandy loams; , sands.

For isolated buildings and small country village where there is no difficulty in obtaining suitable earth and afterwards disposing of it, and where the necessar labour and management can be procured, the system i almost perfect.

The closets may either be used as fixtures or a movable commodes, the latter being intended for use in bedrooms, hospital-wards, etc.

2. Various other modifications of the dry system have been tried or proposed, among which may be mentioned the Carbon Disinfecting and Deodorising Closet of Messrs. Weare and Co., in use in several parts of Liverpool; the charcoal manufactured from street sweepings by the Universal Charcoal and Sewage Company, Limited, at Salford; and the charcoal manufactured from sea-weed by the Carbon Fertiliser Company of Glasgow. With regard to the last Mr. Netten Radcliffe observes that "the examination of the charcoal closets in Glasgow and the vicinity proves, as was to be anticipated, that charcoal properly applied acts as a most effective deodoriser of excrement, and that this action, in receptacles kept dry, persists for an indefinite period. The assumption, however, that the mixed excrement and charcoal may therefore be safely stored for many months in the vicinity of or within the precincts of dwellings, appears to me to be at least premature."

The carbon fertilising process, as patented by Mr. Stanford, has recently been tried at Oldham, but only with varying success. It consists in absorbing excrementitious matter with charcoal, and afterwards drying and carbonising the mixture; thus producing a continually increasing quantity of charcoal, which may be employed in the manufacture of manure, or for other purposes. The principal product of the destructive dis*tillation* is ammonia.

Another closet which works well and which has been ghly spoken of by Dr. Carpenter, Professor Corfield, d Lieut.-Col. Hope, V.C., is the closet known as the ser Dry Closet. It is simple, automatic, and certain its action, and is so constructed that any kind of ilable absorbent material can be used, such as dry th, road dust, powdered charcoal, saw-dust, etc., and her with or without the addition of chemical dis- ectants.

Although other appliances might be enumerated in nection with the dry system, it will be sufficient to nt out that without proper care and supervision this tem possesses no special advantages over the ordinary l system.

With respect to the various systems already referred the Committee on Sewage Disposal reported that "the empts to economise in town-sewering and scavenging removing human excreta separately has been a failure, local costs have been increased, and the local nuisances o, in proportion to the time of retention of the excreta ore removal; there is also the inconvenience suffered trespass on the privacy of the household."

SECTION V.—LIEURNUR'S AND OTHER CONTINENTAL SYSTEMS.

These need only require brief mention. Captain eurnur's system may be described as consisting of air- ht iron tanks situated under the streets, which are nected by iron pipes with the closets in the houses. y means of a powerful air-pump worked by steam the wage is sucked along the pipes to these central tanks, d is afterwards converted into *poudrette.* Only a little ater is used in the closets. The system has been tried Amsterdam, Leyden, and elsewhere; but owing in great measure to its original cost, it has not met with much acceptance. Moreover, it appears to be radically defective in principle, because it is evident that the pipes must become clogged up sooner or later with fæcal matter, and indeed this result is not at all unusual. According to the Seventh Report of the State Board of Health of Massachusetts there is great complaint of the bad odour from the closets when they are situated inside houses, and in order to obviate this nuisance, the people are in the habit of flushing them with large quantities of water. The consequence is that the sewage becomes so much diluted that it could only be converted into *poudrette* at a most ruinous cost.

The *fosses permanentes* of Paris, Brussels, and other continental towns, are huge pits, placed generally under courtyards. They are lined with cement, so as to render them impervious, and are usually ventilated by shafts rising some feet above the roofs of the houses. The contents are removed three or four times during the course of the year by air-tight carts (*tonneaux*), from which the air is exhausted previous to filling, so that the sewage is forced into them through a hose by atmospheric pressure. The closets in connection with the cesspools are almost invariably in a filthy state, from the habit of standing on the seat, which appears to be prevalent in private houses as well as in public places.

The system known as *fosses mobiles* is now adopted in many continental towns, and is a great improvement on the system of *fosses permanentes*. The *fosse mobile* is a closed tub placed on a stand with wheels, and connected by a descent-pipe with the different closets or *faïences* of a house. When filled it is replaced by another of the same construction. The *abfuhrtonnen* of the Germans are of a similar description, but in many of the larger towns the bucket or pail under the privy seat is used (Berlin, Leipsic, etc.)

SECTION VI.—SYSTEMS BEST SUITED FOR RURAL DISTRICTS.

In villages where the scavenging is undertaken by he Sanitary Authority, it is just as essential that some uniform scheme of excrement-disposal should be adopted s in towns, but in the great majority of country villages rovided with sufficient garden space, public scavenging not necessary, because the solid refuse can generally be afely disposed of on the premises. The kind of alteraions, therefore, which may be required to remove privy uisance, will depend very much upon existing arrangements. If, for example, the privy abuts against the ouse, or is not very far from a well, it should either be emoved altogether, or be converted into an earth or ash loset, and be provided with a box or pail to receive the xcreta. "Inside a house," as I have said elsewhere, the only kind of closet which can be used without risk o health must be a water-closet communicating with a rain or cesspool, or a dry closet of an approved pattern; ut in either case the closet must be detached from any iving or sleeping room, and be properly ventilated. In ountry villages, however, the closet accommodation, except in a few of the better class houses, is situated outide, and is of every conceivable description. In the lder villages it is sometimes represented by a rough wooden erection, with a hole dug in the ground to receive he excreta, or more frequently by a sentry-box looking structure stuck somewhere near the far end of the garden, and with a stinking leaky cesspit behind. In more modern villages, however, the privy and ashpit or midden-stead are found combined; but as a rule the ashpit is large and deep, leaky and uncovered, so that at all times it is more or less of a nuisance. Then, again, in the few best class houses provided with water-closets, it is generally found that the soil-pipe is not ventilated, and tha the closet discharges either into a covered cesspool, from which any gases generated can escape only into the house or into a village-drain which was not constructed to receive excremental filth. Such, briefly, are some of the more common varieties of closet-accommodation to be me with in country villages, and I need hardly say that th structural defects connected with them are very often source of nuisance and risk to health. How, then, a these defects to be remedied, legally, in the first plac and with a due regard at all times to efficiency and cost Take, for example, the primitive wooden structure, with the hole dug in the ground to receive the excreta. As a rule, this kind of privy-accommodation is only met with when the cottage itself is old and dilapidated, so that it would be a sheer waste of money to insist on the erection of a new and substantial structure. All that the law demands is to fairly satisfy the requirements of health and decency, and this can be accomplished in the great majority of instances at a very trifling outlay. Let the hole be cleaned out and filled in with fresh gravel or clay, and such other alterations made that a galvanised iron pail or box can be readily inserted beneath the seat to receive the excreta. This, of course, should be regularly emptied into the garden; and to obviate nuisance, dry earth or sifted ashes should be thrown into the pail at least once a day, and in sufficient quantity to keep the excreta covered. If the seat is hinged, there will be no difficulty in removing the pail or in throwing the ashes into it without dirtying the seat. Or take the old-fashioned privy, with its fœtid cesspit behind. This can be readily converted into an inoffensive privy and ashpit combined, by filling up the cesspit to the level of the ground; paving or cementing the filled area, walling it

, and covering it as an ashpit; raising the floor of the
ivy a step, and with it the seat; and placing a flag
ping backwards beneath the seat, so that the excreta
y be readily covered with the sifted ashes or dry refuse
rown into the ashpit. Or the ashpit may be dispensed
th, and, after filling up the cesspit, the privy may be
dily converted into a pail-closet. To sift the ashes,
her a common riddle may be used, or such cinder-sifters
those devised by Dr. Bond, of Gloucester, and Mr. Fox,
Cockermouth. But whatever alterations may be
opted in addition to those required for privacy and
ntilation, the great desideratum is to keep the excreta
y, and prevent undue accumulation. Large, deep, and
covered midden-steads, or ashpits connected with privies,
e always a source of nuisance. When they are nearly
pty, the surrounding soil drains into them in wet
ather, so that for the time being they become open
fensive cesspools, and when full they permit of soakage
to the surrounding soil. Every ashpit, therefore, con-
cted with a privy should be little, if at all below the
vel of the ground; it should be cemented, or made
herwise water-tight, and should be covered (a sloping
rred wooden covering hooked on to the back of the
ivy will do), to keep out the rain. Moreover, it should
of limited capacity, to prevent undue accumulation,
d thereby necessitate frequent removal of the contents.
metimes, in order to keep the contents more or less
y, the ashpit is drained; but apart from the liability to
okage of the drain, and the nuisance arising from the
lmission of liquid excremental filth, drainage of the ash-
it should be prohibited, because, if the ashes do not keep
e excreta dry and inoffensive, the system is a failure."

From these few remarks it will be observed that I
dvocate every possible latitude as regards the way in
hich nuisances connected with privy accommodation

may be removed. In villages, however, for which public scavenging is considered necessary, there is no doubt that some uniformity in the nature of the alterations must be carried out, and I am of opinion that one or other of the pail systems would answer best; as, for example, the Goux system. In rural districts, provided with urban powers, the kind of privy-accommodation supplied for new houses should be carefully considered and enforced; and in one of my own districts I may mention that the closet known as Moser's closet is the one approved by the sanitary authority, although I need hardly say there are many other patents which would answer equally well. Indeed, for new houses any patent of the kind is much cheaper than the old-fashioned privy with its huge deep ashpit, and, what is more, it is a sure preventive against any serious nuisance. But for old-fashioned country villages, where alterations of a limited kind have to be carried out, I do not think that any of the excellent patents to which I have referred are suitable, partly because they are somewhat expensive, and partly, too, because I find that from neglect they do not afford any advantages over the ordinary pail-system. In short, there is no dearth either of adequate appliances or material ready at hand to answer all reasonable sanitary requirements, if we could only get people to make proper use of them.—(See the Author's pamphlet on *Sanitary Defects in Rural Districts and how to remedy them.*)

SECTION VII.—DISPOSAL OF SLOPS.

The term slop-water, as commonly understood, is used to indicate ordinary household liquid refuse exclusive of fæcal matter. For the most part it consists of urine, soap-suds, and the foul-washings from premises generally; and though it may not be considered as ffensive as town-sewage, it frequently gives rise to erious nuisance when it is allowed to fester in rubble rains or stagnant ditches, and is a constant cause of ell-pollution in country districts. In all sewered towns, e slops are of course removed by the ordinary drains d sewers, and even in most villages it is found that eir disposal is in great measure a question of village-ainage in the first instance. But unfortunately, this lage-drainage is so radically defective in the great jority of instances, that pollution of air and water are ke common. The shallow road drains which were tended, when first laid down, to carry off the surface ter, and which, for the most part, are generally conructed of common drain pipes, or loosely laid bricks or nes, have been converted into common sewers by nveying into them the badly laid and open-jointed ains leading from almost every house, or group of uses, in the village. If there be a water-course near e village, the drainage discharges into the stream by e or several outlets, as the case may be, and with what sults it is needless to specify. Should it happen, howver, that the village is some distance from a stream, en it is found that the slops discharge into open itches by the road-side, or into field-ditches in the nmediate neighbourhood of houses, and thereby often ive rise to filthy nuisances in every direction. This escription, it is true, only applies to the worst drained illages, but in almost all of them some of these defects re to be met with. Shallow, unevenly laid, and leaky rains are especially common, and as these are not only iable to pollute any wells which may be near them, but in consequence of the want of proper means of flushing, permit of filth-accumulations, which give off noxious effluvia, they are a source of constant danger.

And this description, it should be remembered, applies to villages in which water-closets do not exist at all, or are very rare, so that the whole of the nuisance may be said to depend upon the disposal of the slop-water. The question, therefore, at once arises whether in any given case a new system of drainage will be required, or the existing system improved to remove nuisance, or whether the slops cannot be satisfactorily disposed of in some other way. If common gutters, as some recommend, are to take the place of drains, it is clear that all the old defective drains must first be taken up and filled in with sound material, and that the gutters themselves should be properly channelled and kept clean. But in the present condition of village-roads, with badly laid side-paths, it is just as evident that these open gutters would be a constant source of nuisance, and hence, in compact villages, or villages of any size, the question of the disposal of slops, is, as I have already said, a question of drainage, and need not be further discussed here. It is sufficient to state that all such drains ought to be well laid, well ventilated, and kept properly flushed, especially in warm weather, by means of a hand water-cart, which could be easily wheeled about by the road-man. (For further remarks, see next chapter.)

As regards scattered houses, or groups of houses which create nuisance by draining into open road-side ditches, such nuisance may be obviated by using the slops in the garden, and if there be not sufficient garden space, I know of no better mode of dealing with them than that devised by Dr. Bond, which consists in the use of a precipitating slop-tub with a filter. Where there is sufficient garden space, and the ground slopes away from the house, the most satisfactory way of treating them is by sub-irrigation, and the use of Field's syphon flush-tank, but care must be taken that the sub-irrigation *drains* are laid at a safe distance from the well. Some-

es the drains lead into what is called a dumb-well;
provided there is no well for drinking water near,
the dumb-well is ventilated and regularly cleaned
this may be regarded as a tolerably safe and ready
hod of dealing with the difficulty. But the multipli-
on of dumb-wells or cesspools in villages, as in towns,
lways attended with danger, and ought to be avoided
nuch as possible.

Section VIII.—Public Scavenging.

Except it be in small scattered communities and
aps, purely agricultural villages, it may be laid down
rule that no semblance of local cleanliness can be
ntained, unless the scavenging, as well as the sewerage
undertaken by the Sanitary Authorities; for, in pro-
tion as dwellings become aggregated, and populations
ease, it becomes more and more difficult for individual
seholders to dispose of their refuse separately. Fortun-
y, in the great majority of agricultural villages there
ufficient garden space attached to the houses to permit
ll events of the safe disposal of the solid refuse on
premises without creating nuisance, or for exceptional
s there need be little difficulty in arranging for its
osal on some closely adjacent land. Arrangements,
example, may generally be made with some neighbour-
farmer, or, as Mr. Haviland has suggested, any excep-
al difficulties which may arise from want of sufficient
len space might be overcome, if Sanitary Authorities
e to provide a spare corner of ground, known as "the
k acre," to which householders could remove their
d refuse. But whenever in any village or town these
iculties are ascertained to be at all common, it then
omes the duty of the Sanitary Authority of the
rict to undertake the efficient scavenging of premises,
er through their own officers, or by contract, and in

case of refusal or neglect, they can be compelled to do so by order of the Local Government Board. In any case, however, the Sanitary Authority is virtually responsible for the cleanliness of its district, either by enforcing the provisions of the Public Health Act for the prevention of nuisance arising from filth-accumulation on individual premises in places to which scavenging does not extend, or by systematically preventing the occurrence of nuisance in places where public scavenging has been introduced.

As regards the general details of public scavenging, much will depend upon local circumstances, and upon the method of excretal removal which may be found to prevail in any particular town. Where the old-fashioned midden system is still allowed to be carried on, the house refuse is mixed with the excreta, and both are carted away together. In the majority of towns, however, the ashes and other solid house-refuse must be collected and removed by a separate system, which necessitates the use of dust-pails or bins, and the daily or frequent visit of the scavenger's cart. For dwellings occupied by single families, the dust-box or pail answers very well, it being large enough to contain the dry refuse collected during the twenty-four hours; and as it is emptied into the scavenger's cart at a stated time daily, any accumulation about the premises is prevented. But in crowded parts, where families live in separate tenements, the whole of the ashes and dry refuse is usually, in the first instance, emptied into a common dust-bin, and afterwards carted away when the bin becomes full. In this case it is necessary that the bin should be roofed in, in order to keep the contents dry, and that it should be well ventilated. No slops or excrement should be allowed to be thrown into it, because the former excite fermentation in the vegetable and animal matters contained in the refuse, and the latter renders the contents offensive. It need

be added that, in a sanitary point of view, dust-
ald be frequently and regularly emptied.

large towns where the pail system of excretal
is carried out, the excrement-pails should be
in specially covered vans, and the ashes and
e-refuse in separate carts. The following is Mr.
Radcliffe's description of the system of scavenging
d on at Rochdale:—

e town is divided into six districts for the pur-
removal, and the dry house refuse is removed at
e time as the excrement, a dust-cart accompany-
night-soil van for the purpose. The removal is
ted during the ordinary working hours of the
vans commencing their rounds at 7.0 a.m., and
at 5.30 p.m. Each night-soil van makes five
laily. It leaves the yard laden with clean empty
ch pail containing a quantity of a 'disinfectant,'
urns carrying the pails containing excrement, for
he empty pails have been substituted. The pro-
substitution is effected by the scavengers with-
from beneath the closet seat the pail containing
nt, covering this up with the lids already de-
removing it to the van, an empty pail being left
ace, and on placing the pail in the van sprinkling
outer lid a little carbolate of lime. The ash-
then carried to the dust-cart, and its contents
tilted into it. Each pail closet is numbered and
d, and the scavengers proceed from closet to
ystematically, according to the portion of their
within the day's beat, revisiting at the end of
und the closets from which the pails had been
, and those, if any, which had been omitted.
atest number of omissions for any one month in
le town has been 42, for any one week, 14.
onday the scavenger's returns are balanced, and

a supplementary van with dust-cart sent out to recti omissions. In the case of lodging-houses and clos used by several families the excrement pails are remo twice or thrice weekly."

In scavenging old-fashioned midden-steads and privi the nuisance is so abominable that the soil-cart can onl make its rounds during the night-time, and even then th stench is so horrible that the air of every street or cour along which the cart passes becomes for the time being positively dangerous to breathe. People who are out late at night may sniff these carts a long way off, and when they do so they generally beat a hasty retreat.

One very important branch of scavenging in urban districts is directed to the cleaning of streets and back courts, many of which are so badly constructed that it is next to impossible to prevent filth-accumulations. Gutters are often so unevenly laid, that after rain or flushing there are small stagnant pools to be seen throughout their whole extent. The surfaces of macadamised streets, again, are being constantly pulverised, and give off clouds of dust containing large quantities of decomposing animal and vegetable matter in dry weather, or are covered with liquid mud when it is wet; while paved streets present numerous insterstices, which cannot be efficiently cleaned out even when scrubbing-machines and flushing are both used. There is no doubt, therefore, that the new plan of street construction which has lately been introduced into some parts of London and other large towns, whether it be wood-pavement or asphalte, and preferably the former, will not only prove to be economical in many ways, but will also be productive o great sanitary advantages. Tar-asphalte, if properly laid is especially applicable to side paths, back courts, an narrow streets, where the traffic is inconsiderable, becaus it is cheap, durable, non-absorbent, and washable.

CHAPTER XII.

PURIFICATION AND UTILISATION OF SEWAGE.

IT has already been shown, in the previous chapter, that of all methods of sewage-removal, the water-carriage system is the one which best meets the requirements of large towns. It is the speediest, cleanest, and, in the long run, the most economical, method which can be employed on an extensive scale, and its general sanitary advantages are now placed beyond dispute. But no sooner had this difficult hygienic problem been solved by engineering skill, than another of even greater difficulty arose. The eagerness of early sanitary reformers to get rid of human refuse at any cost blinded them to the fact that, by pouring sewage into the nearest watercourse, they were merely removing the evil from one place to take effect somewhere else. No consideration was paid to the probable results of the method on the future water-supply of increasing populations, nor to other serious consequences which speedily began to declare themselves. Rivers were in reality converted into sewers, and the communities down stream, while they loudly complained of the annoyance and danger to health, added to the nuisance by following the general example. After a time it was discovered that the mouths of navigable rivers were being silted up, that valuable stocks of fish were destroyed, that water-supplies were contaminated, and that riparian rights were in every sense grossly violated. Such were some of the more important evils resulting from river-pollution, and eventually legal prohibitions were issued in many places to prevent their continuance. These prohibitions have multiplied, until the sanitary authorities throughout the country are at last compelled to purify the sewage of towns before it is discharged into any watercourse at a distance from the sea, or run the risk of incurring legal penalties; while the Rivers' Pollution Act of 1876 absolutely prohibits any new drainage-works which may in future be carried out from discharging into any river or stream without previous purification.

Meanwhile there has been an increasing number of economists who have rightly maintained that sewage was not only wasted, but worse than wasted, when discharged into rivers, and that, on account of its manurial value, its proper destination was the soil. Hence has risen the larger question of the utilisation of sewage, the merits of which will be best understood by considering first the composition of town-sewage.

SECTION I.—TOWN-SEWAGE.

In addition to excretal matters, town-sewage contains the effete products of various trades and manufactures, animal and vegetable *débris,* mineral detritus from roads and streets, and the like, all of which are held in suspension or solution by an amount of water varying according to the water-supply in the first instance, and depending, in the second place, on the rainfall and amount of subsoil-water entering the sewers at different times of the year. This varying amount of water is one of the chief difficulties to be encountered in the utilisation of sewage, and, apart from other considerations, it has led Mr. Menzies and other eminent engineers to recommend the introduction of the pipe-sewer system, which has already been described, into all towns where sewerage-plans have yet to be carried out. The sewage, delivered from pipe-sewers, consisting almost exclusively of excretal matters, slops, and the water supply, can of course be readily estimated in all cases, and is much more easily dealt with. But with common drain-sewers, which receive in addition the rainfall and subsoil-water, not only is the extent of dilution much greater, but it is constantly varying in amount. Thus, to quote the data given in the Third Report of the Sewage of Towns Commissioners (1865), it is considered that 60 tons per head per annum (=36 gallons per head daily) is the average amount of normal or dry-weather sewage in the metropolis; but this amount is further increased by the rainfall and subsoil-water from two-thirds to an equal volume. With pipe-sewers, however, the amount of sewage equals the amount of water-supply, and in towns supplied on the constant system, this ought not to exceed 20 gallons per head daily, or about 33 tons per head per annum. In the face of such considerations as these, the sanitary and practical importance of Mr. F. O. Ward's famous alliterative dogma of "the rainfall to the river, and the sewage to the soil," becomes at once apparent.

But, with either system of sewers, the value of the sewage may be said to depend entirely on the excretal matters, and the amount and relative value of these will be gathered from the following data:—

According to Mr. Lawes, the subjoined table represents, as the result of numerous analyses, the average amount and composition of excretal matter discharged by a male adult daily:—

	Fresh Excrements.	Dry Substances.	Mineral Matter.	Carbon.	Nitrogen.	Phosphates.
	Oz.	Oz.	Oz.	Oz.	Oz.	Oz.
Fæces	4·17	1·041	0·116	0·443	0·053	0·068
Urine	46·01	1·735	0·527	0·539	0·478	0·189
Total	50·18	2·776	0·643	0·982	0·531	0·257

In a mixed population, the actual amounts per individual will obviously be considerably below this average, and, according to Dr. Parkes, they may be estimated 2½ oz. fæcal matter and 40 oz. urine daily, an estimate which gives 25 tons solid fæces for every thousand inhabitants annually, and 91,250 gallons of urine. But the above table also shows that the manurial value of the urine voided in the twenty-four hours greatly exceeds that of the fæces passed in the same time. Indeed, the relative value, as determined by numerous analysts, is approximately as 6 to 1.

The actual value of both urine and fæces in sewage has been estimated by Messrs. Lawes and Gilbert at 6s. 8d. per individual per annum, supposing that 10 lbs. of ammonia is a fair estimate of the amount voided in that time. When the sewage averages 24 gallons daily per individual—that is, 40 tons per head per annum—its money value, according to this estimate, would be 2d. per ton, and the value per ton will decrease in proportion to the rate of dilution above this average. It may be added that this estimate corresponds very closely with the money value of average sewage given in the First Report of the Rivers Pollution Commissioners (1868); for it is there stated that the value of the *dissolved* constituents in 100 tons of average sewage is about 15s., while the *suspended* matters only contain about 2s. worth of them." In other words, 100 tons are worth 17s., or about 2d. per ton.

These monetary details are quoted here because they largely affect the question of utilisation of sewage, and have more or less influenced the various plans which have been proposed or carried out in this direction.

SECTION II.—SCHEMES FOR THE PURIFICATION AND UTILISATION OF SEWAGE.

These have generally been classified under the sepaate headings of precipitation, filtration, and irrigation proesses, and the more important of them are as follows:—

1. *Precipitation processes.*—In all of these processes he main object in view is the purification of sewage by he introduction of chemical agents. The dissolved natters are precipitated to a greater or less extent, and an therefore be separated along with the suspended natters, while the effluent water is supposed to be in a ufficiently pure state to allow of its being discharged into stream or river without producing any serious degree f pollution. It is needless to say that many of them ave proved to be signal failures, chemically as well as inancially. Fictitious values were given to the resulting nanure, and some of the schemes which otherwise might ave proved fairly successful, were simply ruined by being nade stock-exchange speculations. Indeed, it cannot be oo widely known that, no matter what process may be dopted, Sanitary Authorities must be prepared to pay a ubsidy for the chemical treatment of their sewage, ecause it is now clearly established that the manure, or whatever other products may be obtained, will in no case pay, or nearly pay, for the cost of purification. Several of the following processes have been tried and failed, while others are still on trial, and they are given here rather to show what has been attempted in this direction, than as selected instances of success or failure:—

(1.) *Precipitation by Lime.*—This process was at one time carried out on an extensive scale at Blackburn, Leicester, and Tottenham. It consists in mixing the sewage at the outfall works with a certain proportion of cream of lime, when a copious precipitate takes plac which may be sold as manure or converted into brick The supernatant fluid flows off in a comparatively clea though milky condition, but contains about half th putrescible matter of the sewage, and a great proportio of the fertilising constituents. The plan has been pronounced by the Rivers Pollution Commissioners to be conspicuous failure, “ whether as regards the manufactur of valuable manure, or the purification of the offensiv liquid.”

At Northampton, a modification of this process, b the addition of iron perchloride and subsequent filtratio through calcined iron ore, has also been tried, but wit little better results. Other salts, such as salts of zin and manganese, and carbolates of lime and magnesia, hav been proposed as adjuvants to the lime-process, but the all fail in separating the ammonia and other manurin material. They disinfect the sewage for the time bein but do not prevent subsequent decomposition.

(2.) *Blyth's process* consists in the addition of a sal of magnesia and some lime superphosphate, or supe phosphate of magnesia and lime water, with the view purifying the sewage by the formation of the tripl phosphate of magnesia, ammonia, and water. Such precipitate, however, can only take place in water containing an excess of ammonia; so that the whole proces while being more costly than others, was found to be inefficient.

(3.) In *Holden's process,* a mixture of iron sulphat lime, coal-dust, and clay, is added to the sewage, but fails to remove the nitrogenous matters in solution, an indeed increases their amount by dissolving some of th suspended constituents.

(4.) *Bird's process,* which was tried at Cheltenham but abandoned, consists in the addition of crude sulphat lumina, and subsequent filtration through coke. The hate of alumina was obtained by treating pulverised with strong sulphuric acid. In this and Stotherd's ss, which somewhat resembles it, the effluent liquid not found to be sufficiently purified for admission into er without creating a nuisance.

5.) *The "A B C," or Sellar's process.*—This process, h attracted so much attention some few years ago, a prolonged trial at Leamington on an extensive scale, was ultimately pronounced to be a failure. It ists in adding a mixture of alum, blood, clay, charcoal, t of manganese, and other ingredients, to the sewage enters the works. A precipitate is thus obtained, h settles to the bottom of the tanks in the form of a black mud. This is afterwards pumped up into tacles, from which it runs into centrifugal drying ines, or is removed into drying chambers. But in r case it is subsequently spread out on the ground mplete the drying process, and the mass is from time me sprinkled with sulphuric acid to fix the ammonia. ould appear, from the conclusions of the Rivers tion Commissioners, that, though it is superior in respects to the processes already described, it is rtheless an inefficient purifier. It is but right to , however, that more recent experiments conducted at ness with London sewage have yielded somewhat satisfactory results. The experiments were coned during the three months ending November 30, 2, and upwards of 11 million gallons were operated According to the report of Mr. Keates, the analyst r whose supervision the experiments were carried on, ffluent water was clarified to such an extent as to be issible into any ordinary river without producing a erous degree of pollution, nor did he find the manure of the manure to be productive of nuisance. But the value of the manure did not exceed 20s. per ton, and the Committee decided that, considering the cost of the manufacture, the process could not be adopted with any hope of profit to the ratepayers. The works were therefore discontinued. It has since been tried on a large scale at Leeds, but only again to be abandoned.

(6.) *The Phosphate process,* as proposed by Messrs. Forbes and Price, consists in adding to the sewage a solution of the native phosphate of alumina, dissolved in sulphuric or hydrochloric acid, and diluted in water. The resulting manure has been estimated by Dr. Voelcker at £7 : 7s. per ton. The effluent water is clarified and disinfected, but not by any means freed from putrescible or fertilising matters, and the originators of the process have themselves pointed out that it is only intended as a preliminary step to irrigation, where that can be carried out. Where irrigation is impossible, the process is completed by adding milk of lime, to precipitate the phosphates in solution. The process generally has been favourably reported on.

(7.) In *Hillé's process* the mixture consists of lime, tar, calcined magnesium chloride, and some other substance not named. The lime is slaked, and the tar added while it is hot. The whole ingredients are subsequently mixed with water, and flow through a large tap into the tank which receives the sewage. Here precipitation takes place, and the sewage, completely deodorised, passes into a second tank, where the deposit settles. The effluent water is afterwards filtered through a charcoal basket into a third tank, is received into a fourth, and overflows from this into a small brook. The working expenses of the process are small, but the manure is not valuable.

(8.) *General Scott's process* differs from others already described, in the introduction of the chemicals into the sewer at some considerable distance from the outfall.

The precipitating agents consist of lime and clay properly pulverised, and the motion of the sewage in its onward low ensures their thorough admixture with itself before t reaches the outfall. The resulting sludge which is formed, instead of causing any deposit in the sewer, as some anticipated, acts rather as a scouring agent, and keeps the sewer clean. When received into the outfall tanks, the sewage is found to be deodorised, and here the suspended matters are deposited. These are subsequently removed to be dried and burnt, and are thus converted into a useful cement. The drying process, it appears, is not attended with any nuisance.

The British Association Sewage Committee have reported favourably on the whole process, as solving one of the difficulties of the sewage question, namely the separation and deodorisation of the offensive ingredients in an efficient manner, at a comparatively small cost, and of easy application on a large scale. The effluent water, according to the Committee's analysis, contains rather more than two-thirds of the chlorine and of the dissolved nitrogen of the sewage. It is therefore too valuable to be wasted, and too impure to be discharged into a river, and can only be properly dealt with by irrigation.

General Scott's process has been carried on at Ealing, West Ham, and Birmingham.

(9.) *Whitthread's process,* which has also been favourably reported on by the British Association Committee, consists in adding to the sewage a mixture containing two equivalents of dicalcic phosphate, one of monocalcic phosphate, and a little milk of lime. The resulting precipitation was found to be very rapid, and the supernatant fluid clear and inoffensive. Suspended matters were completely removed, and the organic nitrogen nearly so. It was considered by the Committee that the manure would be valuable, as it contained a large amount of lime phosphate and 3 per cent of ammonia. As the effluent fluid contained phosphoric acid and ammonia, it would be suitable for irrigation.

(10.) *Dr. Anderson's process*, first tried at Nuneaton, has been carried on much more successfully at Coventry. It consists in adding an impure sulphate of alumina, made by dissolving aluminous shale in sulphuric acid, to the sewer water, which is kept constantly stirred, and which afterwards flows into a series of settling tanks. The whole of the machinery is admirably planned, and the effluent, especially after it has passed through an adjoining filtering area, is very clear and fit to be discharged into any river. The resulting manure does not command a ready sale, and the works were carried on at considerable loss. Some two years ago, the works were taken over by the Corporation, who pay the Company a fixed sum annually.

2. *Filtration processes.*

(1.) *Simple Filtration.*—In this process the sewage is merely strained or screened, so that, although almost all the suspended matters are removed, the effluent fluid is not by any means purified. The mud which collects at the bottom of the filtering tanks is generally mixed with the town ashes and sold as manure.

(2.) *Carbon*, as in Weare's process, has been tried to purify sewage by filtration, but it does not appear to have been very successful. Very possibly if it could be obtained at a cheap rate and the filtration were made intermittent, it would be found to answer with small quantities of sewage where land cannot be procured. A cheap kind of carbon is now manufactured for this purpose, called *Sanitary Carbon.*

(3.) *Upward Filtration.*—This process was at one time carried on at Ealing, but the results were not satisfactory.

(4.) *Intermittent Downward Filtration.*—Amongst the ous important experiments conducted under the on of the Rivers Pollution Commissioners, there ione attended with better results than the filtration age through a considerable depth of soil. The ments were made on sand, on a mixture of sand halk, and on different soils. The results varied a leal according to the quality of the soil, but in all m it was found that the suspended matters were y removed, and that the organic carbon and nitro-ere greatly reduced. According to the report of ommissioners, "These experiments also show that ocess of purification is essentially one of oxidation, ganic matter being to a large extent converted into ic acid, water, and nitric acid; hence the necessity continual aëration of the filtering medium, which ured by intermittent downward filtration, but en- prevented by upward filtration."

ie process was for some time carried on at Merthyr , according to the plans of Mr. Bailey Denton, C.E.; ie following abstract from the Report of the British ation Sewage Committee will afford a sufficient otion of the various details and the results:—The ig area or farm was about 20 acres in extent, and ts of a very porous gravelly subsoil, covered with ble mould. It was pipe-drained to the depth of 7 feet, the drains conveying to the lowest corner, the effluent water was discharged into a small leading into the river Taff. The area was laid out iare beds, intersected by paths, along which were ucted the main carriers, which received the sewage he outfall sewer, where it was screened through a clay, and distributed it over the beds. In order ply the sewage on the intermittent system, the area ivided into four equal portions, each portion receiv- ie whole of the sewage for six hours in succession, and thus leaving an interval of eighteen hours for rest and aëration of the soil. The surface of the land was cultivated to a depth of about 18 inches, and was laid up in ridges to allow of the sewage running down the furrows. The ridges were planted with cabbages and other vegetables.

The results of the process, as stated by the Committee, were highly satisfactory. All the suspended matters were removed, and the ammonia and nitrogenous organic matters were almost completely oxidised, so that they escaped in the effluent water as nitrites and nitrates. They added, however, that though the sewage was thus efficiently purified, the process could not be regarded as one of utilisation.

Since that report was published in 1872, additional land has been obtained to the extent of 230 acres, and the intermittent downward filtration process has been supplanted by simple irrigation, in order that better returns might be obtained.

The requisite extent of filtering area, as estimated by the Rivers Pollution Commissioners, is 1 acre drained to a depth of 6 feet for every 3300 of the population; but this ratio must vary according to the nature of the soil. The soil should be porous and the surface have an easy slope.

At Kendal, with a population of 13,700, this method has been successfully carried out on an area of 10 acres.

3. *Irrigation.*—It is now generally conceded that this is the only process which fully meets all the requirements attaching to the disposal of sewage; in other words, it is the only one which, while it purifies the sewage efficiently, realises the highest profits, and may be carried on without creating any nuisance or detriment to the health of the neighbouring inhabitants. But in order that the process may be carried out satisfactorily, it is necessary—

(1.) That the acreage be sufficient. This will depend n great measure on the looseness or porosity of the soil; —hence to lay down as a rule that 1 acre should be llowed for every 100 inhabitants, which is the estimate usually given by engineers, is manifestly illogical.

(2.) The land to be irrigated must be drained, and tiff clayey soils broken up and mixed with ashes, sand, r lime.

(3.) The surface must be irrigated on the intermittent ystem, to ensure sufficient aëration of the soil.

(4.) The ground should be laid out in broad ridges nd furrows, the sewage being conveyed along the tops f the ridges in open carriers, and made to flow gently down the slopes by inserting temporary sluices in regular uccession and at regular intervals. At Breton's Farm, near Romford, rented by Mr. Hope, the breadth of the ridge is 30 feet, giving a slope of 15 feet on either side f the carriers. At Lord Warwick's farm near Leamington, Mr. Tough, the manager, informs me that the ridge varies from 50 feet wide according to circumstances.

(5.) There must be a rotation of crops, such as Italian rye-grass, peas, maize, different roots, cabbages, etc., and where land is plentiful, it always pays to let portions of t rest for a time for the growth of cereal crops.

(6.) The sewage should be delivered in a fresh state, nd freed from the coarser portion of its suspended matters. This may be effected either by precipitation, ltration, or screening. At Lord Warwick's farm, the orough of Warwick farm, and the Rugby farm, the wage is simply screened and delivered fresh on to the nd.

Such, briefly, are the principal details connected with wage-farming, and it is the neglect of one or more of em which has brought so much opprobrium on the stem. If the irrigated soil becomes water-logged and

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uch, briefly, are the principal details connected with e-farming, and it is the neglect of one or more of which has brought so much opprobrium on the m. If the irrigated soil becomes water-logged and them a sufficiently purified effluent can be produced for discharge without injurious result, into water-courses and rivers of sufficient magnitude for its considerable dilution ; and that for many towns, where land is not readily obtained at a moderate price, those particular processes afford the most suitable means of disposing of water-carried sewage. It appears, further, that the sludge, in a manurial point of view, is of low and uncertain commercial value ; that the cost of its conversion into a valuable manure will preclude the attainment of any adequate return in the outlay and working expenses connected therewith, and that means must therefore be used for getting rid of it without reference to possible profit.

" 3. In towns where a water-carried system is employed, a rapid flow, thorough ventilation, a proper connection of the house drains and pipes with the sewers, and their arrangement and maintenance in an efficient condition, are absolutely essential as regards health; hitherto sufficient precautions have rarely been taken for efficiently ensuring all the foregoing conditions.

" 4. With regard to the various dry systems, where collection at short intervals is properly carried out, the result appears to be satisfactory, but no really profitable application of any one of them appears as yet to have been accomplished.

" 5. The old midden or privy system in populous districts should be discontinued, and prohibited by law.

" 6. Sufficient information was not brought forward at the Conference to enable the Committee to express an opinion in regard to any of the foreign systems.

" 7. It was conclusively shown that no one system for disposing of sewage could be adopted for universal use ; that different localities require different methods to suit their special peculiarities ; and also that, as a rule, no profit can be derived at present from sewage utilisation.

" 8. For health's sake, without consideration of commercial profit, sewage and excreta must be got rid of at any cost."

To those who are interested in the monetary details of the question, the following table from the report on sewage-disposal by the Committee appointed by the Local Government Board in 1876, gives the cost in different towns by different processes in proportion to the annual rateable value, etc., for the year 1875 :—

.	Population (about.)	Number of Houses.	No. of Water-Closets.	Annual Rateable Value.	Per £ of Rateable Value.	
					Sewage.	Scavenging.
	BY IRRIGATION.					
.	12,000	3,485	2,485	£34,104	1d.	—
.	18,000	3,500	3,000	65,000	1d.	—
.	90,000	16,700	730	235,127	8d.	3½d.
.	45,000	8,725	8,500	217,849	½d.	¼d.
.	20,000	4,000	200	54,407	4½d.	2½d.
.	20,000	4,300	—	68,721	3½d.	—
.	12,000	1,500	1,620	50,000	5¾d.	—
.	24,700	4,500	8,370	113,400	5½d.	1d.
dfil	55,000	10,778	8,000	135,000	7½d.	—
.	8,400	1,700	1,400	45,000	1½d.	—
ells	23,000	5,750	5,635	142,914	10d.	—
.	11,000	2,400	2,000	43,339	6½d.	—
pton	71,000	14,000	750	210,000	2d.	1½d.
.	31,400	—	3,220	163,000	4d.	1¼d.
	BY LAND FILTRATION.					
.	13,700	2,727	450	£44,600	4d.	—
	BY PRECIPITATION.					
.	350,000	83,420	8,000	£ 1,229,844	4¼d.	5¾d.
oors	93,100	18,249	758	311,563	2d.	1½d.
.	285,000	57,000	8,000	945,141	4¾d.	4½d.
.	173,723	34,000	4,050	745,671	3¼d.	2¾d.
	BY THE PAIL SYSTEM.					
.	68,000	11,218	2,600	£262,581	—	4d.
.	67,000	14,388	350	222,000	—	8¾.

SECTION III.—TREATMENT OF VILLAGE SLOPS.

Some slight reference has already been made to this part of the subject in the previous chapter, but the following remarks are submitted in the hope that they may prove of further service in assisting to clear up many of the difficulties in which this important question is involved. They are quoted from the pamphlet on Sanitary Defects in Rural Districts already alluded to, and are an attempt to explain the principles on which my own recommendations have been based, when local circumstances are taken into account:—

"If the village drains into a large stream which is not used for drinking purposes below the village, and provided there is no nuisance at the outfall, I have not considered it necessary to recommend any interference. If, again, the village drains into an open ditch without creating nuisance, it will generally be found that a large catch-pit will suffice, provided all excremental filth and slaughter-house refuse are kept out of the drains. But in all cases in which there is nuisance at the outfall, or risk of water pollution used for drinking purposes, I recommend that the sewage, if it be at all possible, should be purified by irrigation or sub-irrigation, and failing these, that it should be filtered through a filter of sufficient size and on the intermittent downward filtration system. In some localities where the soil is porous, and the quantity of sewage comparatively small, a dumb-well in a field will satisfactorily solve the difficulty, or the outfall drain may be carried alongside a field ditch of lower depth, and the soil between will act as a ready filter. Indeed, in purely agricultural districts, the various expedients which might be easily adopted for the purification and utilisation of village slops are so accessible, so ɔak, that in the great majority of instances there not need be no difficulty in treating them efficiently, but ›perly utilised they will pay a fair return to any r who is public-spirited enough to take them. As ;, however, the method of applying them to the soil 'thing but satisfactory. Very often the quantity is ıall that unless a tank is provided, which can be lically emptied, the sewage trickles along the surface- ' in the field, and finally disappears without con- ing any of its fertilising properties, except it be to des of the gutter, on which some rank grass is found ng. But this insufficiency of volume, which con- es the great objection which farmers have to village ;e, can easily be obviated by constructing one of ɔn and Field's automatic sewage-meter tanks, in ı the sewage can be collected for a period of twelve 'enty-four hours, according to the size of the tank, by means of a self-acting syphon can be readily arged when the tank becomes full. If land has to ırchased, half an acre to three-quarters of an acre of ıd properly drained and laid out would be quite ient to purify the slops and refuse-water of a village ining 800 to 1000 inhabitants, provided the sewage plied on this intermittent system, and the subsoil is ıs. Of course, if simple irrigation should be carried ɔome three or four acres would be required, but in ɔase I should recommend the automatic sewage-meter to secure rapidity and intermittency of flow.

Sometimes the question is raised as to whether ;e slops possess any agricultural value at all. For ›wn part, I am inclined to believe that they possess lising properties quite equal to those of ordinary town ge; and, as an instance in point, I may mention that of the rural sanitary authorities in my district receives ntal of about £6 an acre for a small field laid out in s, which *was purchased* for the purification and utilisation of the slops of an average-sized villag Indeed, any one who takes the trouble to use the household slops in the garden will soon find for himself tha the increase in garden produce will more than compensat for the extra trouble. And here I may remark, that par of the objections which farmers generally have to villag sewage may be fairly attributed to their not unnatura opposition to any village improvements which are likel to increase the rates, and from which they do not receive any direct benefit. In places where both intermittent downward filtration and simple irrigation are objected to on account of their unsightliness, or the possibility of their giving rise to nuisance, the slops of a small village, if separated from the surface water, could be satisfactorily disposed of by sub-irrigation. In short, the difficulties to be encountered with regard to village drainage and purification of slops, as I have already said, are not so much engineering difficulties; the great difficulty in many rural districts is to get anything done at all in this direction.

In sub-irrigation, the drains consist of common agricultural pipes laid at a depth of about 12 inches below the surface upon a bed of larger pipes divided longitudinally in half, so that the slops soak through between the open joints into the subsoil, part of them filtering into the ground, and part of them being absorbed by the vegetation on the surface. The system may be used in gardens, and is specially applicable to land which is reserved for pasture land. Mr. Field recommends that the drains should be taken up and relaid at least once a year, and it is always advisable to have the subsoil deep-drained. Where the system is adopted, as at Shenfield near Brentwood, for separate houses or groups of houses, care must be taken to avoid pollution of the wells by laying a longer or shorter portion of water-tight drain, according to circumstances, between the flush-tank and the sub-irrigation drains.

CHAPTER XIII.

THE EFFECTS OF IMPROVED DRAINAGE AND SEWERAGE ON PUBLIC HEALTH.

HIS subject may be conveniently considered as follows:—

1. The effects of dampness of soil on the public ealth.
2. The sanitary aspects of the water-carriage system f excretal removal.
3. The sanitary aspects of sewage-irrigation.

SECTION I.—THE EFFECTS OF DAMPNESS OF SOIL ON PUBLIC HEALTH.

Amongst the numerous valuable reports which Dr. ichanan, in his capacity of Health-Inspector, has sub- tted to the Privy Council, there is perhaps none which cited greater interest at the time than his report "On e Distribution of Phthisis as affected by Dampness of il." In a previous investigation regarding the effects improvements in drainage and water-supply, Dr. ichanan had ascertained that in certain towns which d been improved in this respect, the mortality from thisis had greatly diminished; and not only so, but e rate of diminution was found to correspond with the tent of the drying of the subsoil. This result, which as so far unexpected, led to the important inquiry above entioned, and the principal facts connected with both ay be briefly summarised as follows:—

In the first inquiry, it was found that wherever the drying of the subsoil had been effected, either by the construction of drain-sewers, or by special drains and deep storm-culverts, when the pipe-system was carried out, the mortality from phthisis had decreased from about 50 per cent downwards. In Salisbury, for example, the death-rates from phthisis had fallen 49 per cent; in Ely, 47; in Rugby, 43; in Banbury, 41; and in 13 other towns, the rate of diminution, though not so marked, was nevertheless noteworthy. On the other hand, it also became apparent that in certain towns, such as Alnwick, Stafford, Morpeth, and Ashley, where no drying of the subsoil had been effected, there was no reduction in the phthisis death-rate, even although the greatest possible progress had been achieved in the removal of filth. This was owing to the fact, that in these towns impervious pipe-sewers had been laid down, without making any provision for deep subsoil-draining, the storm-water being carried off in superficial culverts. In some towns, again, such as Penzance, where the subsoil was already dry, the phthisis death-rate remained stationary; and in others, where plans of drainage had been carried out, the sanitary advantages, as regards phthisis, were nullified, because, as in the case of Carlisle, they were so low-lying that the subsoil was at all times more or less waterlogged. So far, therefore, the relation between dampness of soil and phthisis, as one of cause and effect, became highly probable, and Dr. Buchanan's second inquiry converted the probability into a scientific certainty.

In this special inquiry (see *Tenth Report of the Medical Officer of the Privy Council*) the various registration districts in the three south-eastern counties of England, beyond the limits of the metropolis, were brought under detailed examination, and considered in two ways. Firstly, the true phthisis-rate of the populaion was ascertained, and due allowance made for the auses of the disease which were likely to influence the ate besides the nature of the soil; and secondly, the umbers of the population, in each district, that were und "living upon various kinds of soil, and under arious topographical conditions," were also noted. The sults of these two separate lines of investigation were en brought together, and statistically compared.

Without entering into any of the geological details, hich are fully given in Dr. Buchanan's report, it may e said, generally, that the dampness or dryness of a soil epends partly on whether, if pervious, it is retentive of ater, or, if impervious, the water can readily drain away. gain, it is obvious that pervious soils may present very ifferent degrees of dryness or wetness, according to the levation of the ground, and the dip of underlying npervious beds. Thus, a stratum of gravel or chalk, overing a sloping bed of impervious clay, is necessarily dry soil, because the rainfall readily sinks to and flows long the surface of the impervious slope, whereas the me stratum in a valley may be actually waterlogged, though the depth of the stratum may be the same roughout. Bearing in mind, then, the topographical lations as well as the physical qualities of different ils, the following general conclusions, given by Dr. uchanan as the result of his inquiry, will be at once derstood:—

"(1.) Within the counties of Surrey, Kent, and ssex, there is, broadly speaking, less phthisis among pulations living on pervious soils than among populaons living on impervious soils.

"(2.) Within the same counties there is less phthisis mong populations living on high-lying pervious soils an among populations living on low-lying pervious soils.

"(3.) Within the same counties there is less phthisis among populations living on sloping impervious soils than among populations living on flat impervious soils.

"(4.) The connection between soil and phthisis has been established in this inquiry—

"(*a*) By the existence of general agreement in phthisis-mortality between districts that have common geological and topographical features, of a nature to affect the water-holding quality of the soil;

"(*b*) By the existence of general disagreement between districts that are differently circumstanced in regard of such features; and

"(*c*) By the discovery of pretty regular concomitancy in the fluctuation of the two conditions, from much phthisis with much wetness of soil to little phthisis with little wetness of soil.

"(5.) The whole of the foregoing conclusions combine into one—which may now be affirmed generally, and not only of particular districts—that wetness of soil is a cause of phthisis to the population living upon it."

It is interesting to note that this new discovery in the etiology of disease, which in this country has been associated with Dr. Buchanan's name, had already been brought to the notice of the profession in America by Dr. Bowditch of Boston, U.S. It would appear, however, that Dr. Bowditch's researches were not known in England until after Dr. Buchanan's inquiry had been finished: and although the priority rests with him, the credit of independently establishing causation of phthisis by dampness of soil as a general law in this country remains with Dr. Buchanan. But it would be unfair not to quote Dr. Bowditch's own remarks. In a very able and lucid address delivered to the Massachusetts Medical Society in 1862, he submitted the two following propositions as containing the essential results of very extended inquiry:—

"First.—A residence in or near a damp soil, whether that dampness be inherent in the soil itself, or caused by percolation from adjacent ponds, rivers, meadows, marshes, or springy soils, is one of the principal causes of consumption in Massachusetts, probably in New England, and possibly in other portions of the globe.

"Second.—Consumption can be checked in its career, and possibly, nay probably, prevented in some instances, by attention to this law."

But, in addition to phthisis, there are other diseases whose prevalency is largely affected by dampness of soil. Thus, rheumatism, heart-disease, catarrhal complaints, and ague, are especially common in damp districts; and no greater proof can be given of the sanitary advantages arising from drainage on an extensive scale than the total disappearance of the last-named disease in various parts of the country where it was at one time so common. Moreover, it is evident that in towns situated on damp pervious soils, there is the constant danger of filth-accumulations finding their way by soakage into surface-wells, or, as has previously been shown, the soil may eventually become excrement-sodden, so that the air, as well as the well-water, becomes polluted. It is in this sense that the views of Pettenkofer with regard to the spread of cholera and enteric fever become so important, for he insists on humidity of soil as a necessary factor in the etiology of any localised outbreak of either disease.

An undrained or damp state of soil, especially in populous places, is thus fully proved to be highly inimical to public health, and, according to Mr. Simon, it answers to the legal definition of the term "nuisance." Sanitary authorities are therefore "bound to provide that such a state shall not continue through want of proper constructions for the drainage."

SECTION II.—SANITARY ASPECTS OF THE WATER-CARRIAGE SYSTEM OF EXCRETAL REMOVAL.

So much has already been said with regard to the evils resulting from collections of excretal matter in towns, that, at first sight, the superiority of any system which prevents these accumulations would appear to be placed beyond dispute. Unfortunately, however, the sewer-system is by no means free from serious dangers, and these have at times been attended with such disastrous consequences that many have been led to condemn it altogether. But an examination of a few of the more important outbreaks of disease, which have been attributed to the introduction of sewers, will show that such wholesale condemnation is groundless; that in fact such outbreaks are due to faults in the system, and not to the system itself. Thus, in the first inquiry of Dr. Buchanan, already alluded to (*Ninth Report of the Medical Officer to the Privy Council*), it was found that at Chelmsford the death-rate from enteric fever had increased since the introduction of the sewer-system 5 per cent, and at Worthing it had increased 23 per cent. In both these places, however, there was backing up of the sewage, and, as a consequence, the sewer-gases were forced up into the houses. At Chelmsford, the sewage was received into a tank or underground well; and, at times, when the pumping-engine was not at work, the well filled, and choking of the outfall-sewer, and flooding of the cellars, ensued. At Worthing, again, although there was not so much backing up of the sewage, there was no provision made for ventilation; and hence, in the outbreak of 1865, the disease "almost exclusively attacked the well-to-do occupants of houses on the higher levels, where the water-closets were inside the houses, and almost entirely spared the houses, mostly of a much poorer sort, situated on lower levels, where the closet was placed outside the house. It was not so in the times of cesspools; then these low-lying poor houses were far more attacked with fever than the others." At Morpeth it was also observed that occasional outbreaks of enteric fever had followed times of flood, during which the outfall sewer was under water.

Other instances of a similar character might easily be multiplied, but these are sufficient to show that all such outbreaks are due either to faulty construction, deficient ventilation, or imperfect flushing of sewers, or to backing up of sewage in low-lying towns. But while outbreaks of enteric fever do occasionally take place through the agency of sewers, and amongst others may be mentioned the outbreak at Croydon in 1875, there was no point more clearly established in the whole of Dr. Buchanan's inquiry, than the remarkable reduction of the death-rate from this disease which had taken place in almost all the towns where a proper system of sewerage had been carried out. Thus, in nine of the twenty-five towns examined, the diminution in the number of deaths was over 50 per cent, and in ten others from 33 to 50 per cent, the average reduction being about 45 per cent. The same kind of evidence is also afforded in the account of the sanitary condition of Liverpool, given by Dr. Trench in 1868. Dr. Trench writes:—In 1868 "there raged a wide-spread epidemic of typhoid fever in the town, and in the rural districts of the town. . . . While n the families of the rich, in their costly suburban dwellngs, there was raging a fever, clearly and unmistakably due to the pestiferous emanations from ill-drained cesspools, or other collections of filth or decomposing organic matter; the districts in the borough of Liverpool known as the fever districts, and wherein no midden-steads or cesspools were allowed by the Council to remain unaltered, continued, during the whole period of the epidemic, remarkably healthy and free from fever."

As regards other diseases, it appears that cholera epidemics had been "rendered practically harmless" in all of the twenty-five towns examined by Dr. Buchanan; and in the majority of cases the death-rate from diarrhœa had also been considerably reduced. Moreover, the general death-rate was lowered in some towns over 20 per cent; and the progress made by the inhabitants in cleanliness, decency, and self-respect, was found to be as striking as the improvement in their health measured by the mortuary returns. No doubt, the improved water-supply, which was generally obtained at the same time, aided in the common health-amelioration; but there can be little question that the system of excretal removal by water-closets and sewers was the real agent at work.

SECTION III.—SANITARY ASPECTS OF SEWAGE IRRIGATION.

It has already been shown in the previous chapter that irrigation is the only method of sewage-disposal which sufficiently purifies the sewage, and, at the same time, secures, in some instances at least, a profitable agricultural return. It now remains to be seen whether the carrying out of the system is attended with danger to public health. And here it may be premised that the same difficulty is encountered in sifting evidence as throughout the whole sewage-question,—the difficulty, namely, of dealing with sweeping generalisations which have been based on isolated or exceptional cases. For while, on the one hand, it appears that Dr. Letheby and others have condemned all sewage farms as pestilential *swamps*, Dr. Carpenter of Croydon and other strenuous advocates of the system, so far from pronouncing them as in any way dangerous to health, maintain that the general health of the neighbouring inhabitants is actually improved by them. But this is pushing the argument perhaps too far on both sides. No doubt some sewage farms answer to Dr. Letheby's description, especially such farms as have been laid out, without any due regard to drainage, in low-lying districts, and those that have been planned on the "catch-water" system. It is evident that this latter system necessitates a swampy condition of both soil and subsoil, unless the ground is porous and well drained, inasmuch as the sewage passes over successive areas of land, overflowing from each into a "catch-water" ditch, which conveys it to the next. Again, when the sewage is not delivered in a fresh state, and at least properly strained, if not disinfected by some precipitation process, offensive emanations are undoubtedly given off, especially when the carriers are not kept clean. But though all this is perfectly true, it is no argument against the system when properly carried out, unless direct evidence can be brought forward to show that, even when the engineering and management are alike satisfactory, there is not only possible but actual risk to health. Such evidence, however, does not appear to be forthcoming; and even with regard to farms which have neither been planned nor are conducted according to the most approved principles, the evidence as regards the production of disease is of a negative character. Thus, Sir Robert Christison testifies concerning the Craigentinny Meadows, near Edinburgh—"I am satisfied neither typhus, nor enteric fever, nor dysentery, nor cholera, is to be encountered in or around them, whether in epidemic or non-epidemic seasons, more than in any other agricultural district of the neighbourhood"—(*First Report of the Rivers' Pollution Commissioners*). At Norwood, again, where the farm lies on a deep clay soil, Dr. Cresswell states that the health of the neighbouring inhabitants is in no way influenced by it; and according to the Ninth Report of the Medical Officer of the Privy Council, the irrigation works at Worthing do not cause any description of nuisance or injury to health. So far, therefore, the production of disease arising from fæcal pollution of air or water by the system, when properly managed, is not substantiated. But it was feared at one time that entozootic diseases would be greatly propagated, no matter how efficiently the system might be carried out, and Dr. Cobbold's high authority gave currency to the belief. Dr. Cobbold, however, with rare scientific candour, and after careful investigation, has since stated that the fears which he originally entertained have not been realised. Animals fed on sewage produce have not been found to be parasitically diseased, nor has any case of parasitism been detected in man which could be traced to the effects of sewage-irrigation.

Alarmists, too, have not been wanting, who strenuously maintain that the milk of cows fed on sewaged grass is poor in quality, rapidly decomposes, and is unfit to be used. But so far is this from being the case, that there is an overwhelming amount of evidence to the contrary, and amongst other instances I may mention the following:—Dr. Brushfield, of Brookwood Asylum, states that he has tried the experiment, and found that cows fed on sewaged grass yield more and richer milk than cows fed on ordinary pasture, and this is also the experience of Mr. Tough, the manager of Lord Warwick's farm. Further, Dr. Hill of Birmingham and Dr. Swete of Worcester have frequently analysed both milk and butter, and with the most satisfactory results. It need hardly be said, that on a well-conducted sewage farm, no sewage is applied for several days before the grass is mown, so that it is always perfectly clean.

General Conclusions.—Having regard to the practical as well as sanitary aspects of the whole of this subject, the following points of detail may be noticed:—

1. All towns and villages situated on a pervious or damp soil should be drained.

2. Where there is a good outfall, and no difficulty with regard to the disposal of the sewage, drain-sewers will suffice for drainage as well as for sewage-removal.

3. In low-lying towns, and where the sewage has to e pumped to a higher level at the outfall, pipe-sewers re required.

4. Towns supplied with pipe-sewers should have a eparate system of drainage for the removal of the storm nd subsoil water.

5. Wherever it is practicable, the sewage should be purified and utilised by the process of irrigation, or, where sufficient land cannot be procured, by intermittent downward filtration. Purification by either process will be greatly assisted by previously treating the sewage according to one or other of the most approved precipitation-processes.

CHAPTER XIV.

PREVENTIVE MEASURES—DISINFECTION.

THE remarks in this chapter will have reference chiefly to the prevention of infectious diseases, and to the adoption of measures best calculated to check their progress when they become epidemic, or threaten to become epidemic, in any locality. By infectious diseases is meant all diseases which are communicable from one person to another, whether by actual contact or through the agency of certain media, such as air or water. Many of these, however, are comparatively of such little hygienic concern, that they may be excluded from further notice; as, for example, certain parasitic diseases of the skin, and others, which are never found to affect communities in an epidemic form. The preventive measures, therefore, or other protective means, which will be here considered, apply mainly to the class of diseases termed zymotic, such as smallpox, cholera, typhus fever, enteric fever, scarlet fever, relapsing fever, measles. and the like. Although, in preceding chapters, the mode of propagation of several of these diseases has been considered more or less fully in detail, it will nevertheless be of advantage to allude very briefly to some of the opinions which are entertained concerning their etiology. According to the germ or parasitic theory of infectious diseases, the origin, *de novo,* of a fever poison is as impossible as the spontaneous generation of plants or animals; the inference being *that* enteric fever, for example, can only be developed rom the specific contagium of the fever, just as a case of mallpox cannot occur without infection from some pre-existing case. Now, to this it may be replied that the oisons of all the acute specific diseases must have originated at one time or another independently of pre-existing cases, and there is no reason to believe, therefore, that the causes which led to the development of the first ases should not be in operation at the present day.

The fact is, as Dr. Murchison has pointed out, the uestion at issue has been discussed on too narrow a asis, and the possibility of the several zymotic diseases iffering greatly has been too much lost sight of. Just ecause all of them are infectious, it has been argued hat none of them can be generated except by a specific ontagium. But even as regards this infectious quality, here is the widest possible divergence between them; or while, on the one hand, we find that smallpox and carlet fever are extremely infectious, we find, on the ther, that enteric fever, diphtheria, and erysipelas, have nly a limited power of propagating themselves, except under insanitary conditions which are favourable to their development and spread. Moreover, while, in regard to mallpox, it can never at the present day be traced to any other cause than infection, in diphtheria, it is comparatively rarely that the first case, even of several, can be traced back to any pre-existing case; and the same remark applies generally to sporadic cases or limited outbreaks of enteric fever as they occur in rural and small urban districts. Then, again, it is a matter of almost daily observation that pyæmia and puerperal fever are not only generated *de novo*, but the researches, more especially of Dr. Sanderson, show that they can be generated at will, and when so generated they become, under certain circumstances, eminently infectious. It is no argument, therefore, that because a disease is infectious it cannot be generated *de novo*, and the argument becomes weaker still when it is remembered that several of these diseases do not breed true, nor do they run a definite course. Thus we find erysipelas and pyæmia running into each other, and that either of these, or scarlet fever in its varied forms, may generate puerperal fever in the parturient woman. Without, however, entering farther into the speculative or scientific aspects of this question, I prefer quoting the matured views of Mr. Simon. After dilating upon the influence which filth, and more especially excremental filth, exercises in the development and spread of diseases such as cholera and enteric fever, which, in respect of their leading symptom, may be generalised as diarrhœal, Mr. Simon continues—

"But though hitherto, for convenience of argument, I have referred specially to the influence of human excrement in determining the spread of 'specific' infections from man to man, and provisionally as if man's body were the sole birthplace of the several contagia which afflict his kind, assuredly that intermediary influence is but part, and it may be but a very subordinate part, of the faculty by which filth produces disease. While it is indeed true, as regards some contagia, that at present we know them only as incidents of the human body, wherein we see them in case after case multiplying their respective types with a successivity as definite and identical as that of the highest orders of animal or vegetable life,—and while thus it is at present true, for instance, of small-pox or syphilis, that a case arising independently of a previous like case is hitherto practically as unknown to us as the parentless production of dog or cat, our knowledge with regard to other very important contagia is growing to be of larger scope. I would mention it as among the most hopeful advances of modern preventive medicine, that some diseases, which, in the sense of being le to continue their species from man to man, are appa- ntly as 'specific' as those which I have above named, em now beginning to confess in detail a birthplace terior to man, a birthplace amid controllable conditions the physical nature which is around us, a birthplace mid the 'common,' putrefactive changes of dead organic atter. Referring again now to what I have not pre- nded to be able to analyse in detail—the excess of mis- llaneous, and in great part nominally 'common,' disease filthy neighbourhoods, I would particularly wish to nnect with that subject a reference to our growing ientific knowledge in the matter of the 'common' septic rment. The pathological studies of late years, including ninently certain very instructive researches which Pro- ssor Sanderson has conducted under my Lords of the ouncil, have clearly shown that in the 'common' septic rment, or in some ferment or ferments not hitherto to separated from it, there reside powers of disease- oduction as positive, though not hitherto as exactly efined, as those which reside in the variolous and syphi- tic contagia. Experimentally we know of this ferment, at, when it is enabled by artificial inoculations to act in s most effective way on the animal body, and even more hen it has received a curious increment of strength which s first propagation within the living body seems to bestow n it, it shows itself one of the most tremendous of ymotic poisons. It rapidly in the one animal body de- elops disease, which then is communicable to another: brile disease, with inflammations numerous and intense, nd including in marked degree one of the acutest known orms of intestinal inflammation and flux: disease exactly orresponding to certain very fatal and unfortunately not nfrequent infections to which lying-in women, and per- ons with accidental wounds and the wounds of surgical perations, are most subject, but which also sometimes occur independently of such exceptional states; infections, chiefly known under the names of erysipelas, pyæmia, septicæmia, and puerperal fever; infections which we sometimes see locally arising anew in unquestionable dependence on filth, but of some of which, when arisen, it is perfectly well known that they are among the most communicable of diseases. And a further, perhaps still more instructive, teaching of the artificial infections is this: that the 'common' ferment, which in its stronger actions quickly destroys life by septicæmia, can in slighter actions start in the infected body chronic processes which will eventuate in general tubercular disease. I need hardly point out that the above facts, extremely suggestive though they are, must of course, in relation to my main argument, be applied only under certain reserve; that evidently the exact conditions of the physiological experiment are not reproduced in ordinary life; and that against the common septic ferment, as presented in fouled atmosphere or fouled drinking water, the living human body in its normal state can apparently make considerable (though presumably not unlimited) resistance. But after all such reserves the truth remains, that, looking well at the pathology of human life under residence in foul air, we find ourselves again and again reminded of these results of physiological experiment; often seeing phthisis and other tubercular and like diseases gradually developed, as though under gradual overpowering of the limited normal resistance to the septic ferment; or seeing—and particularly where some exceptional bodily state (wounded or puerperal) gives opportunity—the sudden invasion of erysipelas or other septic infection, not in discoverable dependence on any human infectant, but conceivably a filth-inoculation from the air. The line of reflection thus suggested is one which I cannot now follow farther, but of which the practical interest seems to be extremely great. For, while the excessive production of fatal disease in filthy neighbourhoods is a fact as to which there can be no doubt, and of which the immediate significance is deplorable, the ulterior suggestion is this: that so far as filth in any instance produces anew such a disease as erysipelas or puerperal fever on the one hand, or phthisis or other tubercular disease on the other, the mischief first done is of a sort which entails certain possibilities of extension: such, namely, that in the one instance by accidental contagion, as in the other instance by hereditary transmission, it may, for ought we know, indefinitely extend beyond the sphere in which filth first produced it." —(See Mr. Simon's *Reports*, New Series, No. II.)

But apart from the influence of sanitary defects in the development and spread of infectious diseases, and apart also from the influence of personal susceptibility, which as regards some of them is very great, there are certain other influences obscurely called epidemic, which appear to act as predisposing causes, or, at all events, to give increased energy to causes already in operation. Such epidemic influence, however, is merely the expression of the fact that we cannot always explain why it is that certain diseases should rage with terrible violence in a particular locality at one time and not at another; or why the type of the disease should now be mild and now severe; or why again, a disease, such as cholera, should be subject to periods of pandemic extension. All these are questions which still afford ample room for speculation and research. Meanwhile it is encouraging to sanitary efforts to find that as civilisation advances, epidemics decrease in frequency and intensity, and that nothing tends so much to weaken their power and circumscribe their range of action, as a free circulation of pure air in inhabited places, a good supply of pure water, and a sufficiency of wholesome food.

In preceding chapters the mode of propagation of several of these diseases has been considered more or less fully in detail. It has been shown, for example, that there is good reason to believe that the contagia of cholera and enteric fever are contained in the alvine discharges, which, in their turn, pollute the water-supply or the respired air; that typhus fever is essentially a disease of overcrowding; and that relapsing fever is associated with wide-spread insufficiency of food. It has also been shown, that when the local circumstances which are found to favour the propagation of any one or other of these diseases in an epidemic form are improved, the extension of the disease is checked, and its ultimate extinction from a portion of the community secured. Improvement of local circumstances is, therefore, a most important, and perhaps the most important, part of prevention. But there are other measures which are found to be of immense service in checking the course of any epidemic,—such as the isolation of the sick, the use of disinfectants, and the destruction of the contagia by any other means which may be deemed most efficacious. In order, however, to be able to apply these measures judiciously, some knowledge of the mode of propagation of the several epidemic diseases is essential, and this part of the subject may be briefly discussed as follows:—

SECTION I.—MODE OF PROPAGATION OF EPIDEMIC DISEASES, AND THE PRECAUTIONARY MEASURES INDICATED.

1. *Cholera.*—The basis of precautionary measures with regard to this disease is thus described by Mr. Simon:—"That, when cholera is epidemic in any place, persons who are suffering from the epidemic influence, though perhaps with only the slightest degree of diar-

rhœa, may, if they migrate, be the means of conveying to other places an infection of indefinite severity; that the quality of infectiveness belongs particularly, if not exclusively, to the matters which the patient discharges, by purging and vomiting, from his intestinal canal; that the matters are comparatively non-infective at the moment when they are discharged, but subsequently, while undergoing decomposition, acquire their maximum of infective power; that choleraic discharges, if cast away without previous disinfection, impart their own infective quality to the excremental matters with which they mingle, in drains or cesspools, or wherever else they flow or soak, and to the effluvia which those matters evolve; that if the cholera-contagium, by leakage or soakage from drains or cesspools, or otherwise, gets access, even in small quantity, to wells or other sources of drinking-water, it infects, in the most dangerous manner, very large volumes of the fluid; that in the above-described ways even a single patient with slight choleraic diarrhœa may exert a powerful infective influence on masses of population among whom perhaps his presence is unsuspected; that things, such as bedding and clothing, which have been imbued with choleraic discharges, and not afterwards fully disinfected, may long retain their infectious properties, and be the means of exciting choleraic outbreaks wherever they are sent for washing or other purposes."—(*Eighth Report of the Medical Officer of the Privy Council.*)

The practical applications of the above remarks are therefore these,—that the alvine discharges and vomited matters, as well as any clothing or bedding tainted by them, should be carefully disinfected; and that, if this is carefully attended to, there is little or no risk of infection by direct contact with the patient.

It would be out of place here to refer, except in the briefest terms, to the various conflicting doctrines which have been advanced with regard to the propagation of this disease. Suffice it to say, that while Mr. Simon's views are in full accordance with the experience of those who have most carefully investigated its etiology in this country, the views more especially of Dr. Cunningham, the Sanitary Commissioner of the Government of India, are so entirely opposed to them that it would appear as if the results of all the inquiries which have been so carefully made are absolutely worthless, and that previous investigators have been on the wrong track. In the Ninth Annual Sanitary Report to the Indian Government, he declares in effect, on the evidence of 108 outbreaks, that the transportability of cholera by persons is erroneous, that the water-spread theory of the disease is untenable, and that the influence of tainted air cannot be at present affirmed. According to him, so little is known about the epidemic extension of the disease, that preventive measures are practically of little or no value. It is satisfactory to note, however, that even in India, these views are already beginning to receive substantial refutation; for in his report for the second quarter of 1876, Dr. Payne, the medical officer of health for Calcutta, shows clearly that though other insanitary conditions in the native parts of the city remain unaltered, the introduction of a public water-supply, which took place in 1870, has been followed by a remarkable and continuous diminution in the spread of cholera. Pettenkofer's views have already been alluded to in Chapters VIII. and XIII.; and those who are desirous of studying the European relations of the disease, should read the elaborate report of Mr. Netten Radcliffe, and the abstract by Dr. Seton of the proceedings of the International Congress held at Vienna in 1874, both of which are contained in No. V. of the New Series of Mr. Simon's *Reports*.

2. *Enteric or Typhoid Fever.*—That this disease is

ssentially a filth-disease is alike admitted by those who ccept the doctrine of Von Gietl and Dr. Budd, and those who, like Dr. Murchison and Sir William Jenner, maintain hat it may be generated independently of previous cases. As it occurs in rural and small urban districts, my own xperience leads me to believe that the great majority of cattered cases, and many of the first cases of isolated utbreaks, are due to poisoning of air, drinking-water, or ther ingesta with decomposing filth. Most frequently it s found that the well-water has become polluted by soakge from some drain, cesspit, or manure heap, and in some nstances it would appear as if ill-defined forms of enteric ever, such as those vaguely termed low fever, gastric ever, febricula, and the like, may be caused by decomposing organic matter not necessarily fæcal. But whether he disease is produced by befouled air or polluted water, here is a constantly accumulating amount of evidence which goes to prove that neither the air nor the water need be tainted with the specific contagium of the disease. At the same time, there is no fact more clearly established n preventive medicine than this,—that whenever the disease is developed, the bowel discharges possess an infective power, which, where local conditions assist, can operate with terrible force, and often at long distances from the sick. Indeed, exclusive of the epidemic influence, what has been said with regard to the infective power and the mode of propagation of cholera, applies to enteric fever, and, in the main, the same precautionary measures (see Appendix) are indicated. The evacuations, and any clothing tainted with them, should be thoroughly disinfected. The water-supply should be examined, and in localities where the sewer-system has been introduced, the condition of the water-closets and drains, with regard to ventilation, flushing, and trapping, should be carefully inquired into. Any epidemic of enteric fever in a sewered town points to imperfect ventilation, deficient flushing, or to some faulty construction of the sewers or drains, or to contamination of the water-supply, as in the outbreaks of Sherbourne, Over Darwen, and Lewes (see Chap. VIII.); or to polluted milk, as in the outbreaks in Marylebone, East Moseley, and Eagley (see Chap. II.) In villages and country districts it points to polluted wells, bad drainage, or filthy privies, all of which may originate the disease in the first instance as well as be the means of propagating the specific contagium when it is developed or introduced.

If proper precautions are taken, there is little or no risk that the disease will spread to persons who nurse or otherwise closely attend upon the sick.

3. *Typhus Fever.*—The conditions essential to the propagation of typhus fever are mainly these:—Overcrowding and deficient ventilation; clothing saturated with cutaneous exhalations; squalor and want; a deteriorated state of the constitution from whatever causes; and a moderate temperature.

The disease, once generated, is highly contagious, the contagium being thrown off by the cutaneous and respiratory exhalations. The air of the sick-room is therefore contaminated, and by this means the contagium may attach itself to the walls of the room, or to furniture, or to bedding and clothing, and may long retain its efficacy if fresh air is excluded. Cases are not at all uncommon in which the disease has been communicated to persons who have been employed in cleaning out places which had been occupied by the sick, even though some considerable time had elapsed after the sick had been removed.

But the contagium does not travel far through the air, for, according to Dr. Murchison's observations, it appears that if a patient is placed in a well-ventilated room, the attendants incur little risk, and the other occupants of the house none whatever. Dr. Russell, medical officer of health for the City of Glasgow, has also reported to the same effect, and has, in addition, deduced from his experience other points of practical importance. Thus, in his report on the Fever Hospital for 1870, he writes—"All these facts concur in proving (1) that, where attention is paid to personal and general cleanliness, typhus does not carry far, so to speak, through the atmosphere, and is not portable; (2) close approach to, and contact with, the infected individual and his dirty belongings, lead with great certainty, even in the best sanitary circumstances, and in healthy and well-fed people, to an attack at the end of about four weeks in the great majority of cases, but not in a few until the lapse of some months; (3) that individual susceptibility does not exist, except that which is conferred by a previous attack."

As regards the period of the disease at which the contagium is most powerful, there is a difference of opinion. According to Dr. Murchison the disease is most readily propagated from the end of the first week up to convalescence—that is during the period when the peculiar typhus smell from the skin and lungs is the strongest.

The practical deductions from these observations are as follows:—The sick should be isolated as much as possible; the attendants, by preference, should be those who have been protected by a previous attack; others who visit the sick should avoid coming into close contact with them; the room should be well ventilated by open windows and fires if necessary; all extraneous furniture, such as carpets and curtains, should be removed and disinfected; disinfectants should be constantly used in the room; the bedding and clothing should be disinfected or destroyed; and after convalescence, the whole room, and every piece of furniture, should be purified.

4. *Relapsing Fever.*—Excluding for the present the consideration of the public measures which should be adopted when an epidemic of relapsing fever is raging, the hygiene of the sick-room should be conducted in the same manner as in the case of typhus fever. The disease, however, is much less frequent than typhus, and though contagious in the same way, is not contagious to the same extent. It selects its victims from the poor and ill-fed, who live in crowded, unventilated buildings, rather than from the well-nourished, whose surroundings are healthy.

5. *Smallpox.*—"There is no contagion," writes Sir Thomas Watson, "so strong and sure as that of smallpox; none that operates at so great distance." The contagium indeed may be wafted from house to house on opposite sides of a street, and even with every sanitary precaution, there is great difficulty in preventing its spreading from ward to ward in a large hospital when the disease is prevalent. The poisonous material is thrown off from the cutaneous and mucous surfaces of the patient, and is contained in the exhalations, the excretions, the secretions, the matters in the vesicles and pustules, and in the scabs. It contaminates the air of the sick-room, and attaches itself, as in typhus, to everything contained in the room, or which comes in contact with the patient. Further, it is possessed of great vitality, and if protected from air may remain active for an unknown number of years. The period of incubation varies from ten to sixteen days, though in the majority of cases it does not exceed fourteen. The patient ought not to be pronounced free from infection until all the pustular crusts have fallen off and the whole surface of the body has been well sponged with water and some disinfectant *soap*, or several warm baths have been taken.

Unfortunately, as regards the speedy suppression of outbreaks of this disease, it not unfrequently happens that the first few cases, if of a modified nature, are not correctly diagnosed, the disease being mistaken for chicken-pox or measles. In my own district I have had to report several outbreaks in which mistakes of this description have been made, and I have also been consulted in a few cases when the disease turned out not to be small-pox, as suspected, but either measles or chicken-pox. Of course it is often very difficult to diagnose with certainty an isolated case of either of these diseases, and hence it is very essential that not only should the character of the eruption be carefully scrutinised, but the premonitory and other symptoms, as well as the probable source of infection, should also be carefully inquired into. It need hardly be said, too, that until the nature of the disease is clearly ascertained, every precaution should be taken as regards isolation and other preventive measures. Concerning the protection afforded by vaccination and re-vaccination, as well as other rules of prevention, see Appendix.

The stage of the disease at which the poison is first generated in the person of the sick is not accurately de-ermined, but there cannot be the slightest doubt that, so oon as a case is diagnosed, precautionary measures should orthwith be adopted. If the patient is not at once removed to a hospital, he should be carefully isolated; those n attendance on him should if possible be protected by a revious attack of small-pox or by re-vaccination; and the ame details with regard to the hygiene of the sick-room, disinfection, etc., should be observed, as have already been nsisted on in cases of typhus. All persons living in the ame house or adjoining houses over twelve years of age, hould at once be re-vaccinated, and all children whose accination marks are not large and distinct.

6. *Scarlet Fever.*—Although this disease may attack ersons *of all ages, it* specially attacks children between

the third and fourth year; after the fifth year the cha
of attack decline rapidly. The contagium, like th
small-pox, is exceedingly powerful and volatile, so
no susceptible person can remain in the same roo
any length of time, or even in the same house, unles
patient is carefully isolated, without running great ri
contracting the disease. Moreover, the contagium is
tained in everything which proceeds from the patien
more especially in the cuticular scales given off i
squamation. These scales, laden with the specific p
are conveyed by the currents of air to every part o
room, and may settle on clothing, bedding, furniture,
etc. They preserve their virulence for an unk
period of time, and when disturbed are always lial
reproduce the disease. Thus, there are several inst
recorded in which the fever has been contracted by
ing in a room, which weeks previously had been occ
by a scarlet fever patient; and the fact that the
adheres to articles of clothing is proved by instanc
which the disease has been propagated by the clothi
pupils returning home from school. The cases al
referred to in the chapter on water impurities are a
great interest in showing the absolute necessity o
utmost care and cleanliness to be observed on all
sions, whether the attack is mild or severe. In th
majority of cases, a previous attack confers perm
immunity from the disease.

There is reason to believe that the disease is infe
even before the eruption appears, but, according t
own experience, it is seldom that other cases break
the same family if the first case is promptly remove
hospital, and proper steps are taken to disinfect the
etc. The patient ought not to be pronounced free
infection until desquamation has ceased, and the s
of the body has been well bathed.

The precautionary measures which are indicated by the above remarks are obvious; although it may be admitted that it is impossible to carry them out efficiently in the crowded homes of the poorer classes. But even in homes where no difficulty should be experienced, the necessary isolation and disinfection are too often grossly neglected, either because they are irksome, or, if the case is slight, because they are considered to be needless. With regard to special precautions, see Appendix.

7. *Measles.*—This disease, like scarlet fever, is eminently communicable. The contagium may be conveyed by *fomites,* or by means of the contaminated air of the sick-room. The disease attacks persons of all ages and of both sexes, but is much more frequent amongst children. The risk of infecting commences with the primary fever, and is greatest when the specific eruption is fully developed. As a rule, a patient who has once suffered from the disease is no longer liable to a second attack.

8. *Whooping-Cough.*—The susceptibility to this disease is so strong that few persons have passed the age of childhood without having contracted it. Moreover, the infecting distance of the contagium appears to be very considerable, inasmuch as domestic isolation is frequently found to be of little avail in preventing the disease from attacking other members of the family who have not been protected by a previous illness. That the contagium may likewise adhere to clothing, and may in this way propagate the disease, has been clearly proved by numerous instances.

Such being the mode of propagation of measles and whooping-cough, the precautionary measures which are indicated comprise—isolation of the patient, if other members of the family have not been protected by a previous attack; careful attention to the hygiene of the sick-room, and disinfection of the clothing, bedding, etc. And here it may be pointed out that the prevalence of these two diseases is in great measure attributable to the culpable neglect, arising from the popular belief, amounting almost to fatalism, that children must contract them some time, and that there is therefore little use in endeavouring to take any protective steps when either disease is epidemic. The consequence is that the epidemic continues to spread so long as susceptible victims are to be found in the community, and only dies out for a time when almost all these have been attacked. How far the medical profession are to blame in allowing this popular delusion to retain its hold on the public mind, it would be difficult to say, but until they unite in striving to get rid of the listless apathy which it engenders, the prevalence of such epidemic diseases will continue to be an opprobrium to sanitary science. Nor must it be forgotten that medical men, in the hurry of practice, do sometimes, though unwittingly, convey the contagium of an infectious disease from one patient to another. For example, instances are not at all uncommon in which scarlet fever has been propagated in this way, and the records of puerperal fever contain the histories of many painful cases which could never have occurred had greater care been taken to guard against such fatal mishaps.

9. *Diphtheria.*—Although the etiology of this disease still continues to afford ample scope for research, there can be no doubt that, in its origin and spread, it is intimately associated with sanitary defects. In the majority of the sporadic cases which have come under my own notice, I have every reason to believe that the disease was attributable to polluted drinking water, though in a few others there could be as little doubt that foul effluvia from cesspools, drains, and the like, produced the malady. According to Dr. Thursfield, medical officer of health of the Shropshire Combined District, it is asso-

ciated with dampness of dwellings, and in this respect may, like ague, be largely preventable by the improvement of local conditions. In most cases the severity of the disease is directly influenced by the conditions under which the person attacked is living; and the symptoms become greatly intensified by the disease passing through a person who has newly come into the locality. Diphtheria is more prevalent in rural than in urban districts, and although it may attack adults, it is, like scarlatina, a disease of childhood and early youth. When once the disease becomes developed it is eminently infectious, the contagium being given off principally from the throat and breath, although there can be little doubt that it is also conveyed by the other excretions, and may thus become disseminated through the agency of sewers or closets. In a household and among children, it is often disseminated by kissing, and, indeed, the greatest care ought always to be taken not to bend over the patient so as to inhale the breath. Further, there can be no doubt that the infection is most portable, and may be conveyed long distances in articles of clothing and the like. As in enteric fever, the disease may be spread through the agency of contaminated milk; and according to Dr. Thursfield, the infection can be taken from a corpse, or, at least, from its adjuncta. Of all diseases, not even excepting scarlatina, this is the one most liable to be disseminated through the agency of schools, partly because the symptoms are frequently so mild as not to prevent children from attending school, but chiefly because the disease is peculiarly liable to be spread by the breath, and may be disseminated by the throat after children are sent back to school apparently well. There can be no doubt that the agency of schools in the spread of children's diseases, such as scarlatina, diphtheria, and measles, is becoming all the more potent as attendance becomes better enforced; and there is much need of some measure which would empower sanitary authorities to close schools when necessary, without depriving the teachers of any of their emoluments. The precautions to be taken in respect to diphtheria are much the same as those which are recommended with regard to scarlatina. (See Appendix.)

10. *Diarrhœa.*—Although many are inclined to dispute the grounds on which diarrhœa is classed as a zymotic disease, there is abundant evidence to prove that wherever it becomes prevalent it is due in large measure to insanitary conditions, and that so-called summer diarrhœa is often as distinctly infectious as enteric fever. No doubt there is a considerable amount of diarrhœa, especially that known as infantile diarrhœa, which is due to hand-feeding and other errors in diet; but according to Dr. Johnson of Leicester, who has written a very exhaustive paper on the subject (see *Sanitary Record,* August 15, 1879), out of the 238 deaths which he investigated, as many as 165, or 69·3 per cent of the cases were breast-fed. As is well known, diarrhœa has been exceptionally prevalent in recent years in Leicester, more particularly during the summer and autumn months, and Dr. Johnson was requested by the Sanitary Committee to investigate the causes of the origin and spread of the disease. Dr. Johnson, in his painstaking researches, ascertained that the disease was not limited to the infantile portion of the community, nor was it confined to the most unhealthy parts of the town. He found, however, that after a period of warm and dry weather, the appearance of diarrhœa is hastened; and he attributes the origin and spread of the disease to the presence of bacteria in sewer-air, and the foul effluvia which emanate from cesspools, middens, and other filthy accumulations, and which find a ready entrance into the air of houses. These bacteria were found in the stale food of infants and in the

juices of stale or over-ripe fruit, and they were also detected in the bowel-discharges of patients affected with the disease. He therefore concludes that badly ventilated and stagnant sewers constitute an important factor in the causation of the disease, and that different conditions of drainage account largely for the varying prevalence of diarrhœa in different towns.

In these remarks on the mode of propagation of infectious disease, it has been assumed throughout that the body of the diseased person is the soil in which the germs or infective particles of the disease are multiplied; that these germs, whatever be their nature, are given off by the patient, and may contaminate the air, drinking-water, or other ingesta, or may adhere to clothing, bedding, furniture, or walls of a room; that either directly or after remaining dormant for an unknown period of time, they may infect other persons; and that, by adopting suitable measures, they can be destroyed altogether, or rendered inoperative to a large extent. So far also these remarks have had special reference to the precautionary measures which form a part of personal and domestic hygiene, and which fall under the control and regulation of the private medical attendant. The general proceedings which should be carried out under the advice of a health officer in places attacked or threatened by epidemic disease, are set forth in an official memorandum given in the Appendix.

SECTION II.—DISINFECTANTS.

In the wide sense of the word, the term disinfectant may be defined as any agent which oxidises or renders innocuous decomposing organic matters and offensive gases, which arrests decomposition, or which prevents the spread of infectious diseases by destroying their specific contagia. The term, therefore, includes any agent which possesses deodorising, antiseptic, or fixative properties.

Without entering into any discussion on the *modus operandi* of disinfectants generally (because the subject is still under dispute), it will be convenient for practical purposes to enumerate and describe the most useful amongst them *seriatim*, and without any attempt at classification.

1. *Heat and Cold.*—While extreme cold prevents putrefactive change, and therefore acts as an antiseptic, extreme heat is destructive of all organic matter, and in this respect it is the most efficacious, as it is the most ancient, of all disinfectants. But even a temperature much below that of actual combustion is found to be sufficiently powerful, if continued for any length of time, to kill animal or vegetable germs, and to render inert any contagious matter. Thus, the late Dr. Henry proved experimentally that the vaccine virus was deprived of the power of reproduction when exposed for three hours to a temperature of 140° Fahr., while a temperature of 120° failed to produce this effect. As a result of these and other experiments, he was the first to recommend the employment of the hot-air chamber to disinfect clothing, bedding, and the like; and experience has proved that, when conducted with care, the plan is highly successful. Among disinfecting stoves which have been found to work satisfactorily may be mentioned Dr. Ransome's self-regulating disinfecting stove, manufactured by Goddard and Massey, Nottingham; and the patent disinfecting stove manufactured by Bradford and Co., Crescent Iron Works, Salford.

2. *Charcoal*, and specially animal charcoal, is a powerful deodorant, but there is no evidence to show that it has any effect in destroying specific disease-germs. It oxidises offensive organic effluvia, and is therefore very useful in purifying sewer-gases or other filth emanations.

3. *Chlorine* decomposes sulphuretted hydrogen and ammonium sulphide more certainly than any other gas, and is an energetic destroyer of all organic substances prone to decay. It is especially valuable in purifying rooms which have been occupied by persons suffering from infectious diseases, but it is doubtful whether it can be of much service in the hygiene of the sick-room itself, because, even when largely diluted, it is very irritating to the lungs. It is given off in small quantities by chloride of lime moistened with water, or when employed in scrubbing out the floor. It may also be obtained by adding a little muriatic acid gradually to a wine-glassful of Condy's fluid, or to crystals of potassium chlorate. When required in large quantity for the disinfection of empty rooms, it is most rapidly obtained in one of the following ways:—(1.) To equal parts of common salt and binoxide of manganese add two parts of water, and about the same amount of strong sulphuric acid. (2.) To one part of powdered binoxide of manganese add four parts by weight of strong muriatic acid. (3.) To three parts of bleaching powder add one part of strong sulphuric acid. In any case, the quantities required will depend upon the size of the room.

4. *Nitrous Acid.*—Nitrous fumes are obtained by adding strong nitric acid, diluted with a little water to copper filings. The power of oxidation of organic matter possessed by nitrous acid is very great, and no disinfectant will more readily remove the offensive smell of the dead-house. The fumes, however, are exceedingly irritating and dangerous,—so much so, that this process of disinfection is only suitable for empty rooms, and under skilled superintendence.

5. *Iodine,* though less useful than chlorine, has been recommended as a substitute by Dr. Richardson and others. It is a powerful antiseptic, and may be diffused

through the air of a room by placing a small quantity of the substance on a warm plate, but it is not suited for the sick-room.

6. *Bromine.*—The vapour of bromine can be obtained by exposing a solution of bromine in potassium bromide in open dishes. It was largely used as an atmospheric disinfectant during the American War, but has not found much favour in this country.

7. *Sulphur Dioxide* or *Sulphurous Acid Gas.*—This is exceedingly useful for disinfecting empty rooms. It is obtained by burning sulphur in an earthenware pipkin or other vessel that will not readily crack. It decomposes sulphuretted hydrogen, and as it combines with ammonia, it deodorises or destroys stinking alkaloids, and, probably, disease-germs. Usually fumigation is best effected by burning about 1 lb. of lumps of sulphur for every thousand cubic feet of space in an iron dish (or the lid of an iron saucepan) supported on a pair of tongs over a bucket of water. In a long room it is advisable to burn the sulphur in one or two places in order to secure thorough disinfection.

8. *Carbolic Acid.*—This is one of the most popular disinfectants, and is especially valuable on account of its highly antiseptic properties. In its pure state it is a white crystalline solid, which in a diluted form has been found to be of immense service in preventing putrefactive change in surgical wounds. The commercial article is a thin, tarry fluid, possessing a somewhat offensive odour. It is highly poisonous, and has already been productive of several fatal accidents, on account of its having been mistaken for porter or other fluids. For this reason the carbolic acid powder is safer as a domestic disinfectant. It can be employed in scrubbing out floors, in steeping infected clothing, and in vessels for receiving the excreta. It is also very useful in disinfecting urinals, latrines,

water-closets, stables, midden-heaps, etc. In whatever form, the acid is destructive of the low forms of animal and vegetable life, and arrests or prevents all kinds of putrefactive change. It should never be sprinkled freely about the sick-room, on account of its irritating and disagreeable odour.

9. *Terebene.*—This disinfectant, which has been designed by Dr. Bond of Gloucester, is obtained from spirits of turpentine. It has a fragrant odour, very much resembling that of pinewood, and is powerfully antiseptic. It has been used by Professor Maclean at the Royal Victoria Hospital, Netley, with excellent effects, in correcting the highly offensive evacuations of dysentery, and the fœtor of purulent collections, such as occur in cases of liver abscess and empyema, while, at the same time, it was found to sweeten the air of the wards by diffusing through them its own peculiar pine-like fragrance. It is especially suited as a deodorant for commodes, and as a disinfectant for the bowel-discharges of infectious diseases. It is only slightly soluble in water, but it mixes readily with sweet oil or with benzoline for use in surgical dressings. The experience of its effects gained at Netley shows that it is peculiarly suitable for use in Indian hospitals and in hospitals generally, and it specially commends itself for use in the sick-room.

10. *Cupralum* or *Terebene Powder,* also designed by Dr. Bond, is a combination of terebene with cupric sulphate and potassic bichromate, and possesses the same agreeable odour. It neutralises ammonia and sulphuretted hydrogen, and acts as a powerful coagulator of albumen. It is specially adapted for disinfecting bowel-discharges, water-closets, urinals, and drains.

11. *Sanitas* is another disinfectant which has been highly recommended. It is manufactured chiefly from turpentine and water. As it possesses an agreeable odour,

is non-poisonous, and does not stain, it is well suited for the sick-room.

12. *Condy's Fluid*, red and green, consists of a solution of potassium permanganate. It is essentially an oxidising agent, and as it is odourless, it is a very valuable disinfectant in the sick-room.

13. *Chloride of Aluminium*, or "*Chloralum*," is a powerful disinfectant, and possesses the great advantages of being non-poisonous, inodorous, and very cheap. Professor Wanklyn says that "for removing fœtor and effluvia, it is better and more available than any agent with which I am acquainted. In this respect it is incomparably superior to chloride of lime." Dr. Dougall, after a series of carefully-conducted experiments, likewise maintains that it arrests putrefactive change, and prevents the appearance of animalculæ to a greater extent than any of the commonly employed disinfectants. Not being volatile, it cannot be regarded as an aerial disinfectant, but it is exceedingly useful in washing infected clothing, or as a scouring material for cleansing rooms. It is also an excellent sewage deodorant.

14. *Chloride of Lime* is very useful for disinfecting drains and fæcal matters.

15. *M'Dougall's Powder* consists of carbonate of lime and magnesium sulphite. Like Calvert's carbolic acid powder, it may be employed very advantageously for cleansing purposes, and for the disinfection of masses of putrescent matter, sewage, or excreta.

16. *Sulphate of Copper* has been recommended by Dr. Dougall as possessing antiseptic properties equal to those of chloralum; but it is not so suitable, on account of its price and poisonous nature.

17. *Chloride of Zinc.*—"Burnett's solution" consists of 25 grains of this salt to every fluid drachm. It destroys ammoniacal compounds and organic matter.

hen used, it should be diluted with eight times its
lk of water.

18. *Ferrous Sulphate* or *Green Copperas* has been
rgely used for disinfecting heaps of manure and sewage.
has also been recommended by Pettenkofer to be
dded to cholera evacuations for the purpose of destroy-
g the contagium; but it does not appear to have been
tended with any good results.

Other sewage disinfectants have already been de-
ribed in the chapter on the Purification of Sewage.

19. *Cooper's Salts,* which consist of a compound of
odium, calcium, and magnesium chlorides, have also
een recommended as street and sewer disinfectants.

20. *Potassium Bichromate* has been extolled by Dr.
ngus Smith, and chromic acid by Dr. Dougall, as being
owerful antiseptics, but it is doubtful whether their
rice will ever permit of their being largely employed.

Although the names of other agents could be added
o this list, it embraces all the more useful disinfectants,
nd several which, while they are useful, are not so
ommon. Probably the most reliable amongst them
ay be enumerated as follows:—heat, sulphurous acid,
arbolic acid, Condy's fluid, chloralum, ferrous sulphate,
hloride of zinc, chloride of lime, M'Dougall's and
alvert's powders, terebene, cupralum, sanitas, and char-
oal.

SECTION III.—PRACTICAL DISINFECTION.

1. *Hygiene of the Sick-room.*—In all cases of highly
fectious disease, if the patient is not removed to a
ospital, the first duty to be attended to is the enforce-
ent of a strict domestic quarantine by isolation of the
atient whenever it is possible; the next point is to
ake certain that the room is well lighted and sufficiently
entilated by means of open windows, and fires if neces-

sary; and the third point is to require the instant removal of all extraneous furniture, such as carpets, curtains, and the like. The attendant on the patient should receive strict and precise injunctions, not only with regard to the nursing of the patient, but also with regard to the maintenance of the utmost cleanliness in the room; the disinfection of excreta, slops, soiled linen, etc., and their immediate removal afterwards; and other points of detail depending upon the special nature of the disease and the circumstances of the patient.

Although aerial disinfectants may be regarded as of doubtful efficacy in the sick-room, they are deemed to be useful or expedient by many; and, when properly selected and managed, it may be said, at all events, that they do not do any harm, if they are not productive of much good. The great danger is, that when employed without due precaution, they may only serve to disguise the signs of insufficient ventilation, and in this way conduce to inattention as regards this most essential point. If they are employed at all, they should not be irritating to the patient. Hanging rags steeped in disinfectant solutions about the room is not to be commended, but a sheet moistened with a strong solution of chloralum, sanitas, cupralum, or Condy's fluid, and suspended outside the door of the room, is very necessary to complete the isolation of the patient. The infected clothing, etc., should be received into a tub containing chloralum, sanitas, or carbolic acid, and the ejecta, etc., should be instantly covered with one or other of these disinfectants and removed. Care must also be taken, in using different disinfectants, that they do not counteract each other; for example, carbolic acid decomposes Condy's fluid. Further, the inunction of the body of the patient, in certain of the exanthematous infectious diseases, and especially scarlet *fever*, with camphorated oil, or a mixture of terebene and sweet oil, or a weak solution of glycerine and carbolic acid, followed by disinfecting baths during convalescence, is attended with the best results.

2. *Disinfection of Empty Rooms and Uninhabited Places.*—After a case of infectious disease, the room should be thoroughly cleansed and disinfected. The furniture should be washed with a strong solution of chloralum (three or four ounces to the gallon of water), or with carbolic acid or terebene soap, and the room, as far as possible, emptied. Afterwards the floor and wood-work should also be thoroughly washed with carbolic acid soap, and the paper should be removed. After closing doors, windows, and other openings, sulphurous acid gas should be generated in large quantities in the manner already described, and the room kept closed for several hours. After this, the door and windows should be thrown open, and in a few days the ceiling should be washed with quick lime and whitened, the walls repapered, and the floor and wood-work thoroughly washed with water and some disinfectant soap.

3. *Disinfection of Clothing, Bedding, etc.*—Any material of this description which cannot be injured by being washed, should be steeped in a solution of chloralum or carbolic acid, and boiled. If Condy's fluid be used, the material should merely be immersed, and afterwards rinsed out in cold water, otherwise the solution will stain. In all cases, however, when it can be carried out, the clothing, bedding, etc., are best disinfected by being exposed for an hour at least to a dry heat of about 240° or 250° Fahr., and for this purpose every town of any dimensions should be provided with a hot-air disinfecting chamber for public use. Such a chamber is built of brick, and is heated by a coil of hot-air pipes lying underneath a perforated grating, and communicating with a furnace which opens outside. The one in use in

Dublin cost £400. Dr. Ransome of Nottingham, as already stated, has devised a specially constructed disinfecting chamber, which, while it secures a sufficiency of heat, prevents the articles from being scorched. In connection with every such chamber in large towns there should be a covered van or hand-cart for conveying infected articles, and great care should be taken, by the free use of disinfectants, or by wrapping the articles in a sheet moistened with a strong disinfecting solution, to prevent any risk of spreading disease. A small portable disinfecting chamber is much needed for rural districts.

The hair of infected mattresses should be teased out, fumigated, and exposed to the air, if the mattresses cannot be disinfected in a hot-air chamber. Rags and other articles which can be spared should be destroyed by fire, but so as not to create nuisance. When clothing cannot be disinfected by heat, Dr. Ransome has proposed that the different articles should be placed, layer on layer, in a box, with hot sand or bricks placed at the bottom, and sprinkled over with carbolic acid; but a better plan is to hang them up in a small room, and disinfect them with sulphurous acid gas.

4. *Disinfection of Water-Closets, Urinals, Sinks, etc.*—In any district where an epidemic prevails or is threatening, disinfection of all water-closets, etc., should be carried on systematically, either with solutions of chloride of lime, chloralum, cupralum, carbolic acid, copperas, or Burnett's fluid. Cooper's salts might be used for the streets, lanes, and open courts. Any manure-heaps or other accumulations of filth, which it is inexpedient to disturb or impossible to remove, should be covered with powdered vegetable charcoal to the depth of two or three inches, or with a layer of fresh dry earth, or with freshly-*burnt* lime, if charcoal cannot be obtained. Cess-pits and

idden-heaps may be disinfected with solutions of cop- ras (3 lbs. to the gallon of water), or with cupralum or loralum (1 lb. to the gallon of water). It need hardly said, however, that in a town or district well looked ter by the sanitary authorities, no such filth-accumula- ons would be allowed to take place at any time.

5. *Disinfection of the Dead Body.*—When a patient es of a highly infectious disease, such as small-pox or arlatina maligna, the body should be washed with a very rong solution of carbolic acid or chloralum, or, better ill, enveloped in a sheet saturated with such solution, nd placed in the coffin as soon as possible, disinfectants eing again freely used, and the lid screwed down. The urial should take place without delay; or in crowded istricts, and in towns where a mortuary is provided, the ead body should be at once removed thither. The linen orn by the patient at death, if not buried with the body, hould be destroyed by fire; but when this cannot be one without creating nuisance, the burning should be ffected at some distance from houses, or the bedding may e saturated with quicklime, and buried.

It may be urged that many of these directions are eedlessly minute, and that, in fact, they cannot possibly e carried out in perhaps the great majority of cases. In nswer to such objections, let it be said, once and for all, at no labour is wasted which aims at preventing the pread of disease, even though it be often attended with ilure; and that, however limited be the means or pportunity of carrying out preventive or precautionary easures, such means and such opportunity should always e used, so as to be productive of the best possible results nder the circumstances. Although a number of disin- ectants have been mentioned, it is always advisable that nly a few, and those deemed the most efficient, should e used. Thus, for use in the sick-room, terebene or sanitas appears to be one of the most suitable; for stee ing clothing, a solution of carbolic acid or sanitas; f disinfecting drains, closets, etc., chloride of lime, cupralu or carbolic acid powder; and for fumigation, sulphuro acid gas. For more special directions, see Appendix.

CHAPTER XV.

THE DUTIES OF MEDICAL OFFICERS OF HEALTH.

By clauses 189 and 190 of the Public Health Act 1875, it is enacted that it shall be the duty of every urban and of every rural sanitary authority, throughout England and Wales, to appoint from time to time a legally-qualified medical officer or officers of health for the efficient execution of the purposes of the Sanitary Acts. In the case of rural sanitary districts, such officers may be the district medical officers of unions, who are to a certain extent under the control of the Local Government Board; but in the case of urban sanitary districts, those medical officers of health are alone subject to the control of the Local Government Board whose salaries are partly paid out of monies voted by Parliament. Such sanitary authorities, therefore, who do not choose to receive assistance from the public purse in the payment of their health-officers, may appoint or dismiss such officers without the consent of the Local Government Board, and may issue such regulations for their guidance as they may from time to time determine. In either case, however, the duties of the medical officer of health will, in great measure, be dentical as regards the main points; and hence the following regulations, which have been issued by the Local Government Board for the guidance of medical officers of health whose appointments are made subject to the approval of the Board, may be considered as more or less applicable to all health officers. By an order, dated 11th

November 1872, which is still in force, these duties are thus defined :—

"The following shall be the duties of the medical officer of health in respect of the district for which he is appointed; or, if he shall be appointed for more than one district, then in respect of each of such districts :—

"1. He shall inform himself, as far as practicable, respecting all influences affecting or threatening to affect injuriously the public health within the district.

"2. He shall inquire into and ascertain by such means as are at his disposal the causes, origin, and distribution of diseases within the district, and ascertain to what extent the same have depended on conditions capable of removal or mitigation.

"3. He shall, by inspection of the district, both systematically at certain periods, and at intervals as occasion may require, keep himself informed of the conditions injurious to health existing therein.

"4. He shall be prepared to advise the sanitary authority on all matters affecting the health of the district, and on all sanitary points involved in the action of the sanitary authority or authorities; and in cases requiring it, he shall certify, for the guidance of the sanitary authority or of the justices, as to any matter in respect of which the certificate of a medical officer of health or a medical practitioner is required as the basis or in aid of sanitary action.

"5. He shall advise the sanitary authority on any question relating to health involved in the framing and subsequent working of such bye-laws and regulations as they may have power to make.

"6. On receiving information of the outbreak of any contagious, infectious, or epidemic disease of a dangerous character within the district, he shall visit the spot without delay and inquire into the causes and circumstances of such outbreak, and advise the persons competent to act as to the measures which may appear to him to be required to prevent the extension of the disease, and, so far as he may be lawfully authorised, assist in the execution of the same.

"7. On receiving information from the inspector of nuisances, that his intervention is required in consequence of the existence of any nuisance injurious to health, or of any overcrowding in a house, he shall, as early as practicable, take such steps authorised by the statutes in that behalf as the circumstances of the case may justify and require.

"8. In any case in which it may appear to him to be necessary or advisable, or in which he shall be so directed by the sanitary uthority, he shall himself inspect and examine any animal, carcase, eat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, or lour, exposed for sale, or deposited for the purpose of sale, or of reparation for sale, and intended for the food of man, which is eemed to be diseased, or unsound, or unwholesome, or unfit for the ood of man; and if he find that such animal or article is diseased, r unsound, or unwholesome, or unfit for the food of man, he shall ive such directions as may be necessary for causing the same to be eized, taken, and carried away in order to be dealt with by a justice ccording to the provisions of the statutes applicable to the case.

"9. He shall perform all the duties imposed upon him by any bye-laws and regulations of the sanitary authority duly confirmed, in respect of any matter affecting the public health, and touching which they are authorised to frame bye-laws and regulations.

"10. He shall inquire into any offensive process of trade carried on within the district, and report on the appropriate means for the prevention of any nuisance or injury to health therefrom.

"11. He shall attend at the office of the sanitary authority or at some other appointed place, at such stated times as they may direct.

"12. He shall from time to time report, in writing, to the sanitary authority, his proceedings and the measures which may require to be adopted for the improvement or protection of the public health in the district. He shall in like manner report with respect to the sickness and mortality within the district, so far as he has been enabled to ascertain the same.

"13. He shall keep a book or books, to be provided by the anitary authority, in which he shall make an entry of his visits, nd notes of his observations, and instructions thereon, and also the ate and nature of applications made to him, the date and result of he action taken thereon, and of any action taken on previous eports, and shall produce such book or books, whenever required, the sanitary authority.

"14. He shall also prepare an annual report, to be made at the nd of December in each year, comprising tabular statements of the ckness and mortality within the district, classified according to iseases, ages, and localities, and a summary of the action taken uring the year for the preventing the spread of disease. The report hall also contain an account of the proceedings in which he has aken part or advised under the Sanitary Acts, so far as such pro- eedings relate to conditions dangerous or injurious to health, and lso on account of the supervision exercised by him, or on his dvice, for sanitary purposes, over places and houses that the anitary authority has power to regulate, with the nature and results of any proceedings which may have been so required and taken in respect of the same during the year. It shall also record the action taken by him, or on his advice, during the year, in regard to offensive trades, bakehouses, and workshops.

"15. He shall give immediate information to the Local Government Board of any outbreak of dangerous epidemic disease within the district, and shall transmit to the Board, on forms to be provided by them, a quarterly return of the sickness and deaths within the district, and also a copy of each annual and of any special report.

"16. In matters not specifically provided for in this order, he shall observe and execute the instructions of the Local Government Board on the duties of Medical Officers of health, and all the lawful orders and directions of the sanitary authority applicable to his office.

"17. Whenever the Diseases Prevention Act of 1855 is in force within the district, he shall observe the directions and regulations issued under that Act by the Local Government Board, so far as the same relate to or concern his office."

For the efficient and conscientious discharge of these duties, it is evident that a medical officer of health must make himself thoroughly acquainted with the fundamental principles of public and practical hygiene, with the general and local circumstances which may affect the health of the population in his district, and with the various clauses of the Public Health and other Acts which more immediately concern his office. So much is left to his discretionary power in advising the Sanitary Authority, and in certifying as to what is or is not injurious to the public health, that he cannot but feel the grave responsibility which will devolve upon him, if through ignorance or neglect on the one hand, or through mistaken zeal and want of tact on the other, he fails to carry out his duties honestly, judiciously, and efficiently.

As there is no doubt that considerable difficulty will be experienced at the outset by most health officers in regard to the mode in which their duties should be carried out, the various suggestions and practical details summarised under the following sections, may, it is hoped, prove as serviceable as they are reliable:—

SECTION I. — NATURAL CONDITIONS AFFECTING THE HEALTH OF THE POPULATION CONTAINED IN THE DISTRICT.

These comprise the geological and topographical aracteristics of the district, the water-supply, and the imate.

1. *Geological Conditions.*—Official information as reards these may be obtained from the Ordnance maps and e special sections published by the Surveyor-General; hile fuller details could be readily collected from local urces. In most districts there will generally be found me one who has made the geology of the locality a ecial study.

2. *Topographical Conditions.*—These relate to the tuation of the various parts of the town or district, hether low-lying, elevated, or sloping.

3. *Water-supply.*—The quantity and quality of the btainable water-supply in a district will depend very uch on the two previous sets of conditions. So also ill the nature of the subsoil and the facilities for drainge and sewerage. All this, however, has been fully xplained in previous parts of this work.—(See Chapters I., VIII., and XIII.)

Speaking generally, the diseases which are found to e most largely associated with natural conditions in this ountry are phthisis, and probably also other lung diseases, gue, cancer, rheumatism, heart disease, diphtheria, and oître. In this field of inquiry, Mr. Haviland's writings n the geographical distribution of disease will be found o be very serviceable.

4. *Climate.*—Under this heading are comprised the meteorological conditions of the district, such as the daily temperature, and rainfall, the force and direction of winds,

the barometric pressure, the degree of humidity, and the amount of ozone. In most large towns these observations are already being carefully recorded, and where this is the case, the health officer should endeavour to obtain, through the sanitary authority, the record of the observations weekly. In districts where no such observations are made, it will be no part of his duty to supply this information, but at the same time it is necessary that he should take cognisance of meteorological fluctuations, because they constitute very important factors of health or disease in every district. With regard to the instruments required and the systematic way in which these observations should be made, the short chapter on meteorology in Dr. Parkes' *Manual of Practical Hygiene*, or Buchan's *Handbook of Meteorology*, will give all the needful information.

SECTION II.—ARTIFICIAL CONDITIONS AFFECTING THE HEALTH OF THE POPULATION CONTAINED IN THE DISTRICT; such as—

1. *Habitations of the People.*—So far as possible the sanitary condition of every house in the district should be inquired into. Of course the health officer himself could not undertake such a laborious inquiry, but it could be easily and efficiently carried out by the temporary appointment of one or more competent persons, who would be paid by the sanitary authority and directed by the health officer; while in small urban or rural districts it can be carried out by the sanitary inspector. With regard to this part of the subject, the remarks of Mr. Dyke, the accomplished health officer of Merthyr-Tydfil, are well worth quoting:—" Such an inquiry was made in Merthyr in the autumn of 1866; nearly 10,000 houses were examined and reported on by four intelligent persons; five weeks were occupied in the examination and report,

the cost to the local board being £25. This inquiry embraced the following:—The name of the street, number of each house, names of occupier and owner, number of family and lodgers: the ventilation, how it was secured, whether by back doors, or by windows whose upper sashes could be fully let down; the number of privies or of water-closets, and the state of these; the water-supply, whence derived, and the state of any back premises, noticing particularly whether any animals or poultry were kept. When these returns were completed they were tabulated by the medical officer, for *each street* in *each district*, and the results summed up. The usefulness of these returns has been continuous. They now afford standpoints of reference whence to mark the improvements made, and to note the dark spots that call for amendment; by referring to this 'Dictionary of Habitations,' the state of each house is at once apparent, and upon the occurrence therein of any case of disease, such as, *e.g.* enteric fever or phthisis, the exciting cause, whether excrementitious exhalations or dampness of foundations, may be found."—(*Brit. Med. Journal*, November 16, 1872.)

In carrying out a systematic inquiry of this description in rural districts, it is advisable that the inspector should complete the survey of one or more parishes or villages before submitting the details to the medical officer of health, who would then appoint a day for going over the survey with the inspector. During the inspection he should satisfy himself as to the accuracy of the returns, advise with regard to particular defects, and in this way make himself fully acquainted with the sanitary condition of every part of his district in detail. The tabulated forms to be used for such a survey, when it is authorised by the sanitary authority, will vary slightly, according as the district is urban or rural. Those devised by Dr. Bond of Gloucester, although somewhat bulky, will be found to be well arranged and admirably suited for rural districts. They are published by Mr. Headland, 2 Westgate Street, Gloucester, and contain the following headings in the several columns:—Number; No. of case in nuisance book; date of inspection; situation and description of premises; names of occupier and owner; number of living rooms, sleeping rooms, and inmates; nature, situation, and condition of closet-accommodation; nature of water-supply; defects in drainage, ventilation, or general condition of premises; existence of any special source of actual or possible nuisance; remarks by medical officer of health; additional observations. With very rare exceptions, the inspector will meet with no opposition in carrying out the survey, nor the medical officer of health in obtaining any information with regard to any points which he may consider desirable. Further particulars with regard to the sanitary condition of premises, overcrowding, nuisances generally, and how to draw up reports, will be given in Section IV. (See also Chapter IX.)

2. *Water-Supply.*—In districts where the water-supply is public, the medical officer of health should make himself acquainted with the quality of the water, amount per head, and the risks of pollution, both as regards the source of supply and the mode of distribution. The nature of the supply, whether constant or intermittent, the relation between mains and closets; the situation and condition of cisterns; the separation of cisterns for domestic supply from those supplying closets; the situation of overflow pipes, and the like, are all points which should receive careful attention. In rural districts, the sufficiency of the water-supply, as well as its quality, the situation of wells, and the risks of pollution, should all be duly noted, and samples of suspicious well-water should be examined. In villages where the water-supply is insufficient, it will become a question for the medical officer

f health to advise generally as to how this want may best e remedied, whether by providing one or more public wells, by introducing a public supply, by compelling eighbouring owners of property to unite in providing a ufficient supply under the new Public Health (Water) Act, by storage of the rainfall, or by carting water into he village to meet special emergencies, leaving of course ll practical details to be dealt with by the sanitary engineer or inspector. (Chapters VI. and VII.)

3. *Drainage, Sewerage, Scavenging, etc.*—In towns full nformation with regard to these conditions will be obained from the borough engineer or town surveyor. pecial attention should be given to the ventilation and lushing of sewers, and the condition of house-drains as egards ventilation, flushing, freedom from smell, and fficient trapping; while the ventilation of water-closets, oil-pipes, and, as far as possible, the severance of all irect communication of house-drains with sewers, are dditional points of importance which should not escape otice. The efficiency of the scavenging arrangements hould also be carefully inquired into. In country disricts it will devolve upon the medical officer of health report as to whether the drainage of particular villages satisfactory, and to recommend or not, as he may ink fit, as to whether a competent engineer should be lled in to survey and prepare plans. In certain cases, o, he will have to inquire and decide as to whether blic scavenging has not become necessary to ensure equate local cleanliness. (See Chapters XI., XII., d XIII.)

4. *Factories, Workshops, Bakehouses, Public Institu- ns, Slaughter-houses, etc.*—These should be examined ith reference to overcrowding, air-impurities, and the oduction of nuisances generally. (See Chapter III. d Section IV. of the present chapter.) Factories

already under Government inspection would not of course be subject to the supervision of the health officer, except in so far as they prove to be a nuisance or injurious to the health of the neighbouring inhabitants. In country districts special attention should be given to the sanitary condition of village-schools, whether public or private, and also to the sanitary condition of graveyards.

SECTION III.—VITAL STATISTICS.

In addition to obtaining a full knowledge of the natural and artificial conditions which affect the health of the population, the medical officer of health should also make himself acquainted with the vital statistics of his district. By referring to the more recent Quarterly and Annual Reports of the Registrar-General, the books of the district-registrar, the abstracts of the Boards of Guardians, and any reports which have already appeared with regard to the health of the district, he will obtain all the statistical data representing its vital history for the past few years, as indicated by the number of the population, its rate of increase, the birth-rate, the marriage-rate, the rate of mortality, the prevalency of epidemic or other specially fatal diseases, the death-rate at different ages, the amount of pauperism, etc. From the last census returns, again, he will obtain much useful information as regards the areas, houses, and population, and the ages, civil condition, and occupation of the people.

Amongst other works which will be found very serviceable, are the Digest of the English census of 1871, by Mr. Lewis, and the Supplement to the Thirty-fifth Annual Report of the Registrar-General, published in 1875. This supplement contains Dr. Farr's Report on the Mortality of the Registration Districts of England

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The district registrars throughout the country are instructed by the Registrar-General to forward the returns of births and deaths to the medical officer of health, and are allowed 2d. per entry for remuneration, which the sanitary authority is empowered by the Local Government to pay. The sanitary authority also supplies the blank forms, and defrays the expense of postage. Except as regards deaths from fever or other infectious disease, a return of which should be forwarded immediately, the usual returns of the registrar should be forwarded to the medical officer of health at the close of every week. Blank forms may be obtained from Messrs. Knight and Co., publishers, Fleet Street, London; Messrs. Shaw and Sons, Fetter Lane, London; or Messrs. Farrant and Frost, Merthyr-Tydfil. (See Appendix.)

By means of the information supplied by these weekly returns, the medical officer of health is enabled to tabulate the mortality statistics in such a manner as will show the birth-rate, the total death-rate, the death-rate at different ages, the death-rate from zymotic disease, the connection between the total infantile or zymotic death-rate and the sanitary or insanitary condition of various parts of his district, the prevalency of any particular diseases in certain areas, and so on. If the district is a large urban one, the diseases may be classified according to sub-districts or streets, and if it be a large rural one, they may be classified according to sub-districts or parishes. In large urban districts the classification should be that used by the Registrar-General, or the system recommended by the Society of Medical Officers of Health. (See Appendix.) In small urban or rural districts, however, it is by no means necessary to compile elaborate tables, and the classification which is given in the quarterly returns to the Local Government Board, or some similar classification, will answer all practical purposes. For the sake of comparison it is much to be regretted that some uniform system of classification is not enforced in all districts, a simple system for rural and small urban districts, and a more elaborate system for urban districts containing say 25,000 inhabitants and upwards. In combined districts too, there is some chance of confusion arising from the fact that the registration sub-districts are frequently not conterminous with the several sanitary districts, inasmuch as small urban districts generally form part of a registration sub-district, the other part being included in a neighbouring rural sanitary district.

The first question, then, for the medical officer of health to decide is the system of classification which he may consider it most expedient to adopt; and having decided this, it becomes a simple matter to tabulate the returns week by week, and summarise them monthly or quarterly as the case may be. If monthly reports are submitted, it is the practice in large urban districts to take five weeks for the months of March, June, September, and December, and four for the other months, but in small districts the deaths may be conveniently registered according to the date of death, and not according to the several weeks in which they may happen to be registered. The only objection to this course is the fact that under the present system of registration it sometimes happens that a death does not appear in the registrar's returns until several weeks after it has occurred, and it is therefore customary to enumerate the deaths *registered* from week to week irrespective of the date of death.

After carefully tabulating and correcting the totals of deaths according to sex, age, locality, disease, etc., it often happens that some further corrections must be made for deaths not belonging to the district, which occur in large institutions, such as hospitals, workhouses, and lunatic asylums. Take for example the case of a town of some 10,000 inhabitants in the centre of a union of some

25,000 inhabitants. The town is a separate sanitary district, but contains the workhouse for the whole union. It is evident that the mortality rate for the town would in this case be represented as larger than it really is if no correction were made for the deaths which occur in the workhouse; while, on the other hand, the death-rate of the surrounding rural district would be less than it should be, unless the quota of in-door pauper deaths belonging to it is added. In populous urban districts, however, if the number of deaths occurring amongst strangers be not excessive, they may fairly be included in calculating the death-rate, because in this case they may be considered as representing the deaths of those persons belonging to the district who have died elsewhere.

Coming now to the calculation of death-rates, the first point which has to be determined is the actual or estimated population of the district. The actual population is of course only ascertained every ten years, when the census is taken, or when a house-to-house survey, giving the number of inhabitants in every house, is made. The estimated population, therefore, is the basis on which the birth-rate and death-rate are calculated; and for large urban populations the method pursued by the Registrar-General, and which is lucidly described in a leading article of *The Sanitary Record* for March 1879, should be adopted. In the article in question the population of Sheffield is dealt with by way of illustration, and this is stated as amounting to 185,172 at the census of 1861, and 239,947 at that of 1871, giving an increase of 54,775 persons during the intervening period. The article then goes on to show that "the rate of increase can most conveniently and most simply be calculated by the aid of logarithms. Instead of taking the difference between the population enumerated in 1861 and 1871, the difference between the logarithms of those numbers affords the true method for ascertaining the *rate of increase.* The logarithm of the population of Sheffield in 1861 is 5·2675753, and that of the population in 1871 is 5·3801136; the difference between these logarithms is 0·1125383, which is the logarithm of the rate of increase of population in Sheffield during the ten years 1861-71. If this logarithm of the rate of increase be added to the logarithm of the population in 1871, the number corresponding to this new logarithm will be the estimate of the population at the next census in 1881, which will be found to be 310,922 (or 70,975 more than the enumerated population in 1871). Having obtained the logarithm of the ten years' increase (0·1125383) a tenth of this will give us the logarithm of the annual rate of increase; by inserting a cypher to the left of the logarithm we shall divide it by 10, and 0·0112538 will be the logarithm of the annual rate of increase. The Registrar-General usually estimates his populations, for calculation purposes, to the middle of the year, and as the census is taken at the end of March or the beginning of April, a quarter of the logarithm of the annual rate has to be added to the logarithm of the enumerated population to obtain the logarithm of the estimate for the middle of the year 1871. The logarithm of the annual rate in Sheffield divided by 4 gives 0·0028135, which, added to the logarithm of the enumerated population in 1871, gives the logarithm of the population in the middle of 1871, namely, 5·3829271. Having thus obtained the logarithm of the population in the middle of 1871, the successive addition thereto of the logarithm of the annual rate of increase (0·0112538) will give the logarithm of the population in the middle of 1872, 1873, and so on up to the middle of 1881, by which time a new census will give us a new starting-point. The addition of eight and a quarter times the logarithm of the annual rate of increase to the logarithm of the enumerated population of Sheffield in 1871 gives the logarithm 5·4729575, the number to which is 297,138; this is the Registrar-General's estimate of the population of the borough of Sheffield in the middle of this year.

"The reverse operation, that is, deducting the logarithm of the annual rate of increase from the logarithm of the estimated population in the middle of 1871, will give the logarithm of the population in the middle of 1870; and by repeating this operation the logarithm of the populations in the middle of each of the years back to 1861 may be obtained."

In small and slowly-increasing districts the following method of calculation will give a fairly approximate estimate of the population. Add to the population of the district as enumerated at the last census a tenth of the difference between that number and the number obtained at the previous census for each year that has elapsed since the last census. This will give the estimated population for the end of the first quarter of any given year, that being the period of the year at which the census is taken. But inasmuch as the death-rate is calculated on the estimated population of the district at the close of the second quarter or middle of any year, it is evident that a fourth part of the annual increment, or a fortieth part of the actual increase, of population which has taken place between the two census must be added to represent the increment for the additional quarter.

As regards new and rapidly-increasing districts, however, this method of calculation will not apply, and in such cases it is desirable, when possible, to ascertain the number of inhabited houses for the year, which may generally be obtained from the assessment books. An approximately correct estimate of the population can then be obtained by multiplying the average number of inhabitnts per house, which can be ascertained without much rouble by the number of occupied houses.

After having estimated the population for the year, he next point is to determine the various death-rates. he method adopted by the Registrar-General is thus escribed in another article in *The Sanitary Record*, ugust 7, 1875 :—

> " In the first place it is scarcely necessary to say that all the ates now published by the Registrar-General, whether they relate a year, a month, or a week, are annual rates to 1000 persons ving ; that is, these published rates represent the number of ersons who would die in a year in 1000 of each population, if e proportion of deaths to population recorded in the shorter eriods of a week, or a month, or a quarter, were maintained roughout a whole year.
>
> " Let us take a rate of mortality from the Registrar-General's st weekly return relating to the seven days ending July 31 as an xample. We find in Tables 1 and 2 of that return it is stated at the estimated population of the borough of Sheffield in the iddle of 1875 is 267,881 persons ; that 127 deaths were recorded ithin the borough during the week under notice ; and further, that hese deaths were equal to an annual rate of 24·7 per 1000 of this stimated population. Now for the operation by which this result arrived at. We have the deaths in a week, and the estimated opulation in which they occurred ; it is desired to find the number f the deaths which would occur in each 1000 of this population, the same number of deaths were recorded in each week throughut a year. If a week were the correct fifty-second part of a year, t is obvious that either the deaths must be multiplied by fifty-two r the population be divided by fifty-two, in order to make the opulation and the deaths comparable. As, however, the correct umber of days in a natural year is 365·24226, the number of weeks in a year is 52·17747. The Registrar-General, therefore, or the purpose of this weekly return, divides the estimated population of each of the towns dealt with by 52·17747, which gives what may be called the weekly population of each town. The population of Sheffield divided by 52·17747 gives a weekly population of 5134 persons ; this number serves as constant throughout the year 1875, by which to divide the number of deaths. The 127 deaths in Sheffield during the week ending July 31, divided by this so-called weekly population, gives an annual rate of 0·0247

to each person of the population; and by removing the decimal point three places to the right, or in other words multiplying by 1000, we arrive at 24·7, which is the correct annual rate of mortality per 1000 of the estimated population of the borough of Sheffield during that week. It would undoubtedly be more logical to multiply the deaths by 52·17747, than to deal with the population; but this operation would have to be repeated each week, whereas there is a manifest convenience, and an arithmetical economy, in the reverse operation (the effect of which is, of course, identical), which supplies us with a constant that is applicable throughout the fifty-two weeks of 1875. For all practical purposes the multiplication of the deaths in a week by fifty-two, in order to divide them by the estimated population, will afford the means of arriving at an approximately correct annual rate of mortality; or the reverse operation, the division of the population by fifty-two, may be resorted to.

"For the calculation of annual rates of mortality in a month or a quarter the Registrar-General takes account of the number of days in each month or quarter, and it is found more convenient to deal with the population according to the method described in the calculation of the annual rate of mortality in a week. The populations to be dealt with are divided by 365·24226, and must then be multiplied by the number of days in a month or a quarter, in order to arrive at the population which may be applied to the deaths in a month or a quarter; by this means a scientifically correct annual death-rate in those respective periods will be obtained. Approximately correct annual rates of mortality in a month or a quarter may be calculated by using a twelfth or a quarter of the population respectively, as the divisor of the number of deaths recorded in those periods; but, inasmuch as the length of a month varies from twenty-eight to thirty-one days, and of a quarter, from ninety to ninety-two days, it is evident that a correct annual rate of mortality can only be calculated by taking into account this variation in the number of days in those periods, and that rates calculated without correction for these inequalities will differ from the rates published by the Registrar-General.

"In conclusion, it may be noted that rates published in the quarterly returns of the Registrar-General for the eighteen largest English towns relate to the period of thirteen weeks most nearly corresponding with the natural quarter, and that the population employed in this calculation is thirteen times that used for the rates in each week, and differs slightly from the population that would be used if the period of observation were three entire calendar

> onths instead of thirteen weeks. The facts published in the quarerly return for all other parts of the country, except the eighteen argest English towns, relate to the natural quarters of three calenar months, and the population used to produce the annual rates of ortality therein are manipulated in the manner before described."

Although the method of calculation thus described hould be adopted in dealing with the statistics of all arge towns and populous districts, a less complicated ethod will give sufficiently accurate results for small rban or rural districts. Thus we will suppose that the umber of deaths registered in a district with an estiated population of 11,342, during a quarter of the year mount to 56, the annual death-rate per 1000 represented y this number would be approximately determined as ollows:—

$$\frac{56 \times 4 \times 1000}{11{,}342} = 19{\cdot}7.$$

esides the annual death-rate, the other rates which are sually given in statistical reports are the birth-rate, the ate of infant mortality, and the death-rate from zymotic isease.

The birth-rate is, of course, calculated in the same ay as the death-rate, and is stated at so many per 1000 er annum.

The rate of infant mortality is usually measured by he proportion of deaths under one year to births registered, and is also expressed as so many per 1000. Thus, we will suppose that the deaths of children under one year of age during the quarter amounted to 28, and that the births during the same period amounted to 225; the rate of infant mortality estimated in this way will therefore be:—

$$225 : 1000 : : 28 : X,$$

$$\text{or } X = \frac{28 \times 1000}{225} = 124.$$

Or the rate of infant mortality may be stated as a percentage of the total deaths. For example, let us suppose in the above instance that the deaths during the quarter amounted to 126, the percentage of deaths of children under one year will then be:—

$$\frac{28 \times 100}{126} = 22{\cdot}2.$$

The zymotic death-rate, or for that matter the death-rate from any disease or class of diseases, is calculated in the same way as the total annual death-rate, and is expressed as so many per 1000 of the population. Thus, we will suppose that in a population of 22,438, the deaths from the seven principal zymotic diseases, as stated in the Registrar-General's returns during the year, amounted to 48; the zymotic death-rate per 1000 would in this instance be:—

$$\frac{48 \times 1000}{22{,}438} = 2{\cdot}1.$$

If it be desired to calculate the death-rate among persons of any given age, it is of course necessary to ascertain approximately the number of persons living in the district at that age, and this information can be obtained from Vol. III. of the last Census Report. In making the calculation, it may be fairly assumed that the estimated population at all ages is distributed in the same proportions as was the enumerated population in 1871.

In order to calculate the mean age at death of a population, all the ages at death, during a given period, are added up, and this sum is divided by the total number of deaths. The mean age at death in England is about forty years.

In drawing conclusions from statistical data, it need *hardly* be said that great care must be taken to guard against fallacies. For example, the death-rate of the whole of a district may be comparatively low by reason of the preponderance of adult or selected lives, while the sanitary conditions are anything but satisfactory; or, again, the total death-rate may still not be above the average, while the death-rate in certain portions of the district may be excessively high. Indeed, as regards the special value of death-rates as a test of sanitary condition, it has been urged by the late Dr. Letheby, Dr. Tripe, and others, that they are utterly fallacious and unreliable on account of certain disturbing influences, such as the varying proportion of the two sexes in a population, the varying proportions of persons living at different ages, the influence of estimates of population in impairing the value of death-rates, and the effect of migration. It has, however, been clearly shown by Mr. Humphry (see *Sanitary Record,* 1874), that even if the maximum of influence were accorded to these disturbing causes, the resulting differences are exceedingly small, and as a matter of fact they have always been taken into account by the Registrar-General so far as circumstances would allow. But while this holds good in respect to large populations, there is no doubt that some of these disturbing influences do affect the death-rates of small urban and rural districts very materially. For example, there is a small urban district under my own supervision, which in 1874 contained an *enumerated* population of 828, and the death-rate for the year was as low as 6·1 per 1000, while in 1875 it was only 12 per 1000. In this instance the exceptionally low death-rate is accounted for by the preponderance of adult and selected lives, there being in the majority of houses in the district a large staff of servants. In another urban district similarly circumstanced with an estimated population of 2047, which I have reason to believe is not over the mark, the death-rate for 1875 was only 9·4 per 1000. Now, although it be true that as regards both these districts the sanitary condition is ver satisfactory, it is evident that, comparing them with othe districts, the death-rate would be no reliable test of th condition. These are, of course, exceptional instances, b many others might be quoted to show that the total deat rate, while it may be considered as a test of some consi erable value as regards the sanitary condition of large communities, cannot be depended on when commenting upon the vital statistics of small urban or rural districts.

Generally speaking, the effects of sanitary improvements and precautionary measures are best indicated by a lowered death-rate from infectious diseases, fever, diarrhœa, and phthisis, and, amongst children under five years, from all causes. Indeed, it may be said that the death-rate of children under five years of age is in many places a far more reliable criterion of the sanitary conditions affecting the health of a community, than the total average mortality rate, even although every allowance is made for neglect, deficiency of food, mal-nutrition, and exposure. Nor, again, in drawing inferences from mortality returns, must the influence of social causes of disease be forgotten, for the effects of intemperance, immorality, and injudicious marriages, especially amongst the lower classes in all our large towns, can scarcely be over-estimated. Indeed, there is no doubt that drink and immorality have as large a share in producing a high death-rate amongst crowded populations as the insanitary conditions of their homes and their surroundings.

In these plain and practical hints it is not necessary to discuss the more complicated problems of vital statistics. What is required of the medical officer of health is that he should classify his returns honestly and with no preconceived ideas as to what the figures are to prove; and although mistakes may sometimes be made in diagnosis, he is bound to classify the returns as he receives them, unless after due inquiry he is convinced that in exceptional cases such mistakes have been made. Even then it is essential, as a statist, that he should present the returns as they are sent in to him; and if he has reason to question their accuracy, he should honestly state his reasons, after as far as possible consulting with the medical attendant. This of course is always a delicate matter, requiring the utmost tact and conscientiousness, because under any circumstances it is an interference liable to be resented, and especially if the medical officer of health is not precluded from practice. But, whether the medical officer of health is in practice or not, enough has been said to show not only the necessity of constant and systematic attention on his part to the vital statistics of his district, but also the immense assistance which a logical use of them will afford him in estimating rightly the separate or combined influences of avoidable or removable causes of disease.

SECTION IV.—DUTIES REQUIRED OF THE MEDICAL OFFICER OF HEALTH FOR THE EFFICIENT EXECUTION OF THE SANITARY ACTS.

As the health officer must "be prepared to advise the sanitary authority on all points involved in the action of the sanitary authority or authorities," it is necessary that he should make himself acquainted with the Public Health Act of 1875, and the other Acts or portions of them which more immediately concern his office. Previous to the consolidation of the various Sanitary Acts in the Public Health Act of 1875, the task of wading through these numerous enactments, so as to obtain a practical knowledge of the clauses affecting the duties of the health officer, was by no means an easy one. All this, however, is now very much simplified, an the only Acts which the health officer need consult, ma be confined, with a few exceptions, to the Public Heal Act, 1875, the Artizans' Dwellings' Act, 1875, the Ca Boats' Act, 1877, and the Public Health (Water) Ac 1878. And here it may be observed that though the Public Health Act permits the medical officer of health to exercise any of the powers with which an inspector of nuisances is invested, it is not his duty to search for nuisances. By all means let him make an inspection whenever he deems it necessary, or when he has reason to believe that the sanitary inspector is not properly attending to his duty, but he should avoid as far as possible interfering with matters which in the first instance concern the office of the surveyor or sanitary inspector. He should nevertheless be fully qualified to advise and give suggestions, and in order to do so it is essential that he should be well acquainted with practical details. The clauses in the Public Health Act, to which special attention should be directed, are classed in order as they appear in the list, under the following headings:—

1. *Sewerage and Drainage* (clauses 13-26).—The two most important clauses in this section, so far as the medical officer of health is concerned, are, clause 19, which makes it incumbent on every local authority to have all sewers constructed, ventilated, and kept, so that they shall not be a nuisance; and clause 23, which empowers local authorities to enforce the drainage of undrained houses, such drainage to be carried out in all particulars to the satisfaction of the surveyor. (See Chapter XI.)

2. *Privies, Water-closets, etc.* (clauses 35-41).—These clauses give full powers to sanitary authorities to enforce closet accommodation, and to provide that all drains, water-closets, earth-closets, privies, ashpits, and cesspools,

ithin their district, be constructed and kept so as not to e a nuisance or injurious to health. With regard to ructural details, and especially the alterations which are quired to remedy the defects which are so commonly nnected with the closet accommodation of rural districts, e Chapter XI.

3. *Scavenging and Cleansing* (clauses 42-47).—By rtue of these clauses, sanitary authorities are empowered, r they may be required by order of the Local Governent Board, to provide for the cleansing of streets and e removal of refuse; and in localities where the scaveng g is undertaken by the sanitary authority, any occupier f premises may claim a penalty not exceeding five shilngs a day from the local authority if they neglect, after ue notice, to cleanse any earth-closet, privy, ashpit, or sspool, belonging to such premises. In all cases, therere, where the medical officer of health is convinced that blic scavenging has become necessary, he ought to urge at this duty be undertaken by the sanitary authority, d if they refuse to comply with his request, he should ve no hesitation in appealing to the Local Government ard to issue the necessary order. In places where ere is no public scavenging, the local authority may ke bye-laws imposing the duty of cleansing footways d pavements adjoining premises, and of removing all ensive refuse from the premises, on the occupier. ause 46 gives power to order the cleansing and purify g of houses on the certificate of the medical officer of alth; and clause 47 imposes penalties in respect to rtain nuisances occurring on premises in urban districts. ee Chapter XI.)

4. *Offensive Ditches and Collections of Matter* (clauses 3-50).—These clauses provide for the obtaining of orders r cleansing offensive ditches lying near to or forming e boundaries of districts; for the removal of filth-accu-

mulations on the certificate of the sanitary inspector; and for the periodical removal of manure from mews and other premises in urban districts.

5. *Water-Supply* (clauses 51-70).—These clauses relate to the general powers of sanitary authorities for supplying their districts with water, whether by water-works or wells; to provisions for the protection of water-supplies against pollution; and to the closing, cleansing, or repairing of polluted wells. (See Chapters VI. and VII.)

In the Public Health (Water) Act 1878, power is given to enforce a wholesome supply for isolated houses or groups of houses if within a certain limit of outlay; and it is further enacted that no house which has been newly built or rebuilt shall be occupied unless such wholesome supply is first provided. The Act applies specially to rural districts, and if systematically carried out, will be of immense service in improving the health of these districts.

6. *Regulation of Cellar-Dwellings and Lodging-Houses* (clauses 71-90).—Besides prohibiting the occupation of cellars absolutely, or only under certain conditions, these clauses provide for the registration of common lodging-houses, and the issuing of bye-laws for their regulation, and they also empower the Local Government Board to authorise the local authority to make bye-laws in respect to houses other than common lodging-houses which are let in lodgings, or occupied by members of more than one family. As regards watering-places, and other fashionable health-resorts, this last provision is one of great importance, inasmuch as it would not only ensure the removal of any sanitary defects from houses let in lodgings, but it also renders it compulsory on lodging-house keepers to give immediate notice to the sanitary authority in cases of infectious disease, and to take proper precautions. For proposed bye-laws see Appendix.

7. *Nuisances* (clauses 91-111).—As this section of

the Public Health Act is a very important one, it may be considered more fully in detail. The several classes of nuisances are defined by the Act as follows:—

(1.) "Any premises in such a state as to be a nuisance or injurious to health."

It need hardly be said that this definition, by reason of its vagueness, includes a great variety of sanitary defects, and, like the other definitions, implies injury to health, whether probable or actual, as a consequence of the nuisance. Unfortunately, too, this vagueness is, if possible, still further increased by the definition in the preamble of the Act, which states that "*lands* and *premises* include messuages, buildings, lands, easements, and hereditaments, of any tenure." All this gives ample room for legal quibbles, but, so far as the duties of the medical officer of health and the sanitary inspector are concerned, there is usually little difficulty experienced in carrying out the intention of the Act. The sanitary defects implied in the definition have reference, for the most part, to the cleansing or whitewashing of dirty houses; the repair of roofs that let in the rain; the repair of walls and uneven floors; the opening of fastened windows to improve the ventilation; the removal of privies or pigstyes abutting against outside walls; the prevention of dampness as far as possible; the repair of yards, and, especially in rural districts, the sanitary improvement of farm-yards adjoining the dwelling-houses. When it is not possible to put a house into habitable repair, or when the necessary repairs are not carried out in compliance with the notice issued by the sanitary inspector, power is given, by clause 97, to close the house by order of a Justice. With regard to the difficulties of dealing with the question of defective house-accommodation, see Chapter IX.

(2.) "Any pool, ditch, gutter, water-course, privy, urinal, cesspool, drain, or ashpit, so foul, or in such a state as to be a nuisance, or injurious to health."

This definition requires no further comment than this, that whenever any offensive smell is given off by any pool, ditch, etc., whether it be in the proximity of dwellings, or near any frequented road or footpath, there is sufficient evidence of the existence of a nuisance which calls for removal. All foul privies, cesspools, and drains in rural districts can be dealt with under this clause.

(3.) "Any animal so kept as to be a nuisance or injurious to health."

This definition applies to pig-styes, fowl-pens, dog-kennels, cow-byres, etc. In dealing with nuisances of this description, it often happens that the abatement may be effected in various ways. For example, a nuisance arising from a pig-stye may be abated sometimes by keeping the animal in a more cleanly way, by lessening the number of pigs, by properly draining the pig-stye, by removing the pig-stye if it be too near a dwelling, or too near a frequented path, or by prohibiting the keeping of pigs altogether. It may safely be laid down as a rule, that pig-styes close to dwellings, or under bed-room windows, will always be more or less a nuisance, no matter how carefully the animal may be kept.

(4.) "Any accumulation or deposit which is a nuisance or injurious to health."

In this definition are included offensive manure-heaps, or other filth-accumulations, which are close to dwellings or frequented paths. It also applies to offensive refuse-heaps of every description,—the only exception being made "in respect of any accumulation or deposit necessary for the effectual carrying on any business or manufacture, if it be proved to the satisfaction of the Court that the accumulation or deposit has not been kept longer than is necessary for the purposes of the business or manufacture, and that the best available means have been taken for preventing injury thereby to the public health."

(5.) "Any house or part of a house so overcrowded as to be dangerous or injurious to the health of the inmates, whether or not members of the same family."

In previous parts of this work the necessity for an ample amount of cubic space for the requirements of perfect health has been strongly insisted on—an amount, however, which it is impossible to obtain or enforce in the dwellings of the poorer classes, and in common lodging-houses. Practically it is found that 300 cubic feet per head is the highest *minimum* which can be enforced in most large towns, and even that amount cannot be exacted in the case of many families consisting of husband and wife and young children. In rural districts also the difficulty of dealing with this form of nuisance on reasonable and equitable grounds is quite as great as it is in towns, if not greater; and as an instance in point, I may quote the following remarks from one of my reports for 1874:—"In places where there is a scarcity of houses, it is evidently impossible to abate the nuisance to any extent, because in attempting to reduce the overcrowding in one part you only increase it elsewhere. But in Mid-Warwickshire this difficulty has not arisen, partly because the district is mainly agricultural and can only maintain a limited number of the labouring class, and partly, too, I have no doubt, because during the last two or three years there has been a considerable exodus from a good many of the villages in consequence of the agricultural labourers' movement. The cases of overcrowding met with have been generally confined to single families occupying houses with only one sleeping-room, and in endeavouring to deal with this form of nuisance there were several points which had to be considered. In the first place, it was clear that if the minimum allowance of cubical space per head was made too high, the instances of overcrowding, judged by this standard, would have become so numerous that any attempt to deal with them would have been impossible; in the second place, the ages of the children had to be taken into account; and in the third place, it became a question whether, in condemning a house as being too small for the family, another and suitable one was to be found in the village. With regard to cubical space, it appeared to me, after careful inquiry into the average amount of sleeping accommodation, that the standard of 200 cubic feet per head was as high as it could be raised for families consisting of parents and young children, though at the same time I am free to confess that a minimum of 300 cubic feet space, even with good means of ventilation, is little enough for the requirements of health. But in cases where it was found that grown-up children of both sexes slept in the same room, or in the same room with their parents, the question of cubic space became a matter of secondary consideration, and the plea of overcrowding has been insisted on in the interests of decency as much as on the score of health. It will thus be seen that the cases of overcrowding met with had to be decided according to the special circumstances of each rather than in accordance with any fixed rules, and though the minimum cubic space which has been adopted is small, it must be borne in mind that the dilapidated state of most of the cottages permits a freer interchange of air than is usually to be obtained in newer and better built houses. All this is, of course, an admission that only the more glaring cases of overcrowding have been dealt with; but with so many cottages containing only one sleeping-room, and taking into consideration the size of the rooms, it is impossible to lessen the extent of the evil except by acting on principles such as these. As it is, many cases of overcrowding have been abated, and the notices issued by the Inspectors have been so generally complied with that only a few cases had to be brought before the Magistrates."

(6.) "Any factory, workshop, or workplace (not already under the operation of any general Act for the regulation of factories or bakehouses), not kept in a cleanly state, or not ventilated in such a manner as to render harmless, as far as practicable, any gases, vapours, dust, or other impurities generated in the course of the work carried on therein, that are a nuisance or injurious to health, or so overcrowded while work is carried on as to be dangerous or injurious to the health of those employed therein." (See Chapter III.)

(7.) "Any fireplace or furnace which does not, so far as practicable, consume the smoke arising from the combustible consumed therein, and which is used for working engines by steam, or in any mill, factory, dyehouse, brewery, bakehouse, or gas-work, or in any manufacturing or trade process whatsoever; and any chimney (not being the chimney of a private dwelling-house) sending forth black smoke in such quantity as to be a nuisance, shall be deemed to be nuisances liable to be dealt with summarily in manner provided by this Act;" provided always that it can be shown that the best practical means have been adopted to consume the smoke, having regard to the manufacture or trade, and that due care has been exercised by the person in charge of the same.

In order to obviate nuisances of this description, all furnaces or factory fire-places should have chimneys of sufficient height, and should be provided with a smoke-consuming apparatus. Very often it is found that nuisance arises from neglect in stoking.

8. *Offensive Trades* (clauses 112-115).—By these clauses power is given to urban sanitary authorities to

restrict the establishment of offensive trades in their districts, such as bone-boiling, soap-boiling, tallow-melting, etc.; to make bye-laws with respect to the same; and to direct complaint to be made before a justice, if the effluvia given off are certified to be a nuisance or injurious to health, by the medical officer of health, or by two legally-qualified practitioners, or by any ten inhabitants of the district. Before a conviction can be obtained in respect to established trades, it will be necessary to prove to the satisfaction of the court that the best practical means for the abatement of the nuisance have not been adopted and as the medical officer of health is liable in most cases to be called upon to give skilled evidence, it is necessary that he should be well acquainted with the process of manufacture, or the details of the trade complained of, the nature of the effluvia given off, and the best means which should be adopted to prevent nuisance. Such knowledge can, of course, only be obtained by inspecting offensive trades, and it must necessarily be supplemented by a thorough acquaintance with practical chemistry. Unless the medical officer of health is an expert in these matters, the best course to pursue is to recommend the manufacturer or tradesman, against whom complaint is made, to call in some competent person to advise him as to what steps he should take to prevent nuisance; and in the event of no steps being taken, he should recommend the sanitary authority to consult an expert, who would give evidence before the magistrates if necessary.

With proper precautions the manufacturer of offensive products may, in the greater majority of instances, carry on his trade without causing serious nuisance to the neighbourhood, and not unfrequently finds it advantageous even as regards pecuniary interests when he is compelled to utilise his waste offensive refuse. Without entering into details, it may be said generally that all foul matters should be conveyed to the works in properly-constructed vans or tanks, which can be covered with tight-fitting lids, and that they should be stored in closed chambers or tanks, ventilated, if necessary, into the furnace fires, or to special scrubbers. All foul processes, such as oil-boiling, tallow-melting, and the like, should be carried on in boilers with tight-fitting lids, and the effluvia given off should be conducted first to a condenser to get rid of the steam, if necessary, and then to the furnace-fire to be consumed. The sulphuretted hydrogen and ammonium compounds which are given off in the manufacture of salts of ammonia from gas-liquor, should also be conducted from the vats to the furnace-fire to be burnt. Again, all gases and vapours which can be condensed or absorbed should be passed through condensers or absorbents specially suited for them, as, for example, water in the form of spray, or scrubbers charged with water, sulphuric acid, or alkaline solutions.

In Dr. Ballard's valuable report concerning offensive trades, already referred to in Chapter III., he thus classifies the ordinary sources of origin of effluvium nuisances:—

"1. Accumulation of filth on or about the business premises, or on its removal from the premises in an offensive condition.

"2. A generally filthy condition of the interior of the buildings and the premises and utensils generally.

"3. An improper mode of disposing of offensive refuse, liquid or otherwise.

"4. Insufficient and careless arrangements in the reception of offensive materials of the trade, or in the removal of offensive products either from the premises, or from one part of the premises to another.

"5. An improper mode of storing offensive material or offensive products within the works.

"6. The escape of offensive gases or vapours given off during some part or parts of the processes to which the materials of the trade are subjected into the atmosphere outside the works."

The report contains abundant illustrations of the modes in which effluvium nuisances may arise from business premises, and is replete with information concerning methods in use, or which may be devised to obviate or minimise them; but without referring to particular trades it will be sufficient to indicate the general principles on which prevention should be based, and these are laid down by Dr. Ballard as follows:—

"As respects the first and second of these sources of effluvium nuisances, the obvious remedy is 'cleanliness' in the broadest sense of the word.

"1. Filth should be removed from the premises speedily in the impervious covered vessels in which it ought always to be collected from time to time during the day.

"2. Those parts of the interior of premises liable to become dirty or encrusted with filth or decomposible matter, and all the utensils employed, should be regularly cleansed. Such structural and working arrangements should be made as shall not only tend to prevent such defilements, but also tend to facilitate cleansing.

"3. Solid refuse should be separated from liquid refuse as far as practicable, and each should be disposed of in its appropriate manner, the solids being deposited and speedily removed in covered impervious vessels, and the liquids being run off into proper drains in such a condition as not necessarily to give rise to offensive emanations. Deodorants may sometimes be used with advantage.

"4. Offensive matters necessary for use in the business should be brought upon the premises either in covered impervious vessels, or covered up in such a manner that they shall not be a source of effluvium-nuisance in transit. They should be so received in an enclosed building, and unloaded with due precaution against the issue of effluvia in the process. Offensive products should be removed similarly from the premises. Precautions should also be used in the removal of offensive products from one part of the premises to another. Difficulties in this respect now and then arise in works from insufficient space, or bad arrangements of workshops and receptacles. In such cases as these, modifications may be necessary in the works themselves.

"5. Offensive materials and products of the business should either be stored in impervious vessels or in a close chamber, ventilated, if necessary, in such manner that the effluvia shall not become a nuisance.

"6. Sometimes a careful selection of the materials of the manuacture, or some little modification of the manner of conducting a art of the process, may be sufficient to obviate an effluvium nuisance holly or partially. But when the evolution of offensive gases or apours is not thus avoidable, they must be intercepted in their assage to the external air, and dealt with in such a manner as to estroy their offensive character. One method of interception conists in arrangements for drawing off in a continuous manner the air f the entire chamber or workshop in which the offensive effluvia are volved; but mostly the interception is practicable without doing this. Vhen drawn off or collected, they may, according to their nature, be ealt with in one of five ways:—(1.) They may be discharged into he atmosphere at such an elevation as that they shall be so diluted efore reaching the ground as not to be offensive. When this will ot suffice, other means must be used. (2.) If the evolved matters e condensible by cold, they may be passed through an appropriate ondensing apparatus. (3.) If soluble in water, they may be subnitted to the action of water in an appropriate apparatus, or simiarly, to the action of any other liquid better calculated to absorb hem. (4.) Sometimes, in like manner, solid substances, with which the effluvia have chemical affinity, may be used with advanage, either in powder or otherwise. (5.) If the evolved matters be combustible, they may be burned by conducting them through a fire."—(*Supplement to Local Government Board Report,* 1876.)

9. *Unsound Meat, etc.* (clauses 116-119).—These clauses empower the medical officer of health or inspector of nuisances to inspect and examine, at all reasonable times, "any animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, flour, or milk, exposed for sale, or deposited in any place for the purpose of sale, or of preparation for sale, and intended for the food of man."

In carrying out his duties in this respect, it is advisable that the medical officer of health, when he is not alled in by the sanitary inspector, should get that officer, r failing him a policeman, to seize the condemned rticles in order to have them dealt with by a justice. he onus of proving that the article seized was not exosed or deposited for sale, or for preparation for sale, or was not intended for the food of man, rests upon the person charged. Very often, with regard to bad meat, the defence set up is that the article seized was not intended for the food of man, but for feeding dogs, or to be boiled down with other offal as the case may be. So far, however, as the medical officer of health is concerned, he should endeavour, as far as possible, to confine his evidence to the question as to whether the article seized is or is not fit for the food of man, leaving the rest of the evidence to be given by the sanitary inspector or other witnesses. Various practical hints concerning the examination of different articles of food have already been given in Chapter II., while medical officers of health, who are also appointed as public analysts under the "Sale of Food and Drugs Act, 1875," must be specially qualified.

10. *Infectious Diseases, Hospitals, Mortuaries, etc.* (clauses 120-143).—This part of the subject has already been so fully discussed in previous chapters that little more remains to be said. The medical officer of health will have to consider whether, in the event of an outbreak of epidemic disease occurring in his district, there can be procured at short notice sufficient means of isolation. It is true that in some rural districts the population is so very scattered that hospital accommodation is not required, because sufficiently protective measures can be adopted by quarantining, as far as possible, any infected houses, and by supplying properly trained nurses, if they should be wanted, who may be paid either by the sanitary authority, or, in the case of paupers, by the board of guardians. When an outbreak threatens to be serious, a strict watch should be kept on all houses where infectious disease is known to exist, and there should be no hesitation in summoning any one who wilfully or carelessly offends against any of the clauses of the Act. In order that there may be no excuse for pleading ignorance in *this* respect, the sanitary inspector should be supplied

with placards containing the necessary precautions to be taken (see Appendix), a copy of which he should leave at every infected house. In inquiring into the origin of any outbreak, or in giving instructions with regard to preventing its spread, it need hardly be said that the medical officer of health should be very careful not to examine any case without first requesting the sanction of the medical attendant, and unless he has reason to believe that an error has been made in the diagnosis, he should never question the accuracy of any returns which may be made to him. He will also have to consider whether it is necessary that any schools should be closed, and in recommending that such a step should be taken, he should always give a certificate in the case of public elementary schools, in order that the teacher may not be deprived of the government grant which is allowed on the average attendance of the pupils.

With regard to the special provisions of this section of the Act, it may be pointed out that it is imposed as a duty on all sanitary authorities to cause premises to be cleansed or disinfected, and they are further empowered to direct the destruction of any bedding, clothing, or other articles, which cannot otherwise be safely disinfected, and to pay for the same; to supply means of disinfection if necessary; and to provide ambulances, hospitals, and mortuaries. They may either build such hospitals or places of reception, or contract for the use of any such hospital, or part of a hospital, or place of reception; or enter into any agreement with any person having the management of any such hospital; or two or more authorities may combine in providing a common hospital. In populous districts, it is always advisable that a proper hospital should be erected; and in small urban and rural districts, it will often be found that such hospital accommodation can be most economically and efficiently provided by combination of neighbouring authorities. The term place of reception will include any house which may be rented for the reception of infectious cases, or any hut or tent, or, in the case of seaport towns, any hospital ship.

Clause 132 empowers a sanitary authority to recover the cost of maintenance of any patient who is treated in any such hospital, who is not a pauper; but inasmuch as the removal of a patient to a hospital may be said to confer as great a benefit on the public as it does on the patient, the enforcement of payment would not only be manifestly unfair in many cases, but would tend greatly to diminish the usefulness of such hospital. According to clause 124 the only persons who can be removed to an infectious hospital by order of a justice, on a certificate signed by a legally qualified practitioner, are the following:—any person who is suffering from any dangerous infectious disorder, who is without proper lodging or accommodation, or lodged in a room occupied by more than one family, or is on board any ship or vessel; or any person so suffering who is lodged in any common lodging-house. With proper tact, however, on the part of the medical officer of health in enlisting the co-operation of medical attendants, and readiness on the part of the sanitary authority to attend to his recommendations, there will generally be little difficulty experienced in inducing most patients to enter the hospital who are fit to be removed, and whose removal is considered advisable for the public safety.

Although the sanitary protection afforded by hospitals, mortuaries, disinfecting apparatus, and the like, is now placed beyond dispute, it unfortunately happens that sanitary authorities, as a rule, are very slow to exercise the powers vested in them in this respect, unless under the pressure of an epidemic, and consequently the recommendations of the medical officer of health to be prepared beforehand are often thrown aside. But this need not discourage or annoy him in any way. His plain duty is to study carefully the requirements of his district, and having done this, to submit his views as clearly and as concisely as he can to the sanitary authority, using the best arguments he can advance to support his case, showing every readiness to answer any questions, and being fully prepared to meet any objections. If his recommendations are not complied with, the onus will rest on the sanitary authority, and not on him; but at the same time he should be careful to bring them forward on some future occasion, when very likely they will either meet with acceptance, or at all events some efforts will probably be made to carry them out.

Clauses 134 to 140 empower the Local Government Board, whenever any formidable outbreak takes place in any part of England, to make regulations for the speedy interment of the dead, for house-to-house visitation, for medical aid and accommodation, and for other means to prevent the spread of disease; but it will only be in cases of the gravest emergency, and when the health of his district is seriously endangered, that the medical officer of health will feel it incumbent on him to recommend the enforcement of these clauses.

In all cases of infectious disease, care should be taken to ensure as far as possible the right use of disinfectants, and it is always a wise economy on the part of sanitary authorities to supply disinfectants gratuitously to those who are too poor to buy them. Moreover, as it is the duty of the sanitary authority to take care that disinfection is efficiently carried out, the sanitary inspector, under the direction of the medical officer of health, should himself superintend or assist in the process of the disinfection of rooms, etc., or in populous districts some one should be specially appointed to act as a disinfector.

For detailed information with regard to hospitals, infectious disease, etc., see Chapters X. and XIV., and Appendix.

11. The other clauses in the Public Health Act which are of special interest to the medical officer of health are the following, and they apply exclusively to urban districts, or districts provided with urban powers:—

Clause 157 gives power to make bye-laws respecting new buildings, etc.

Clause 164 empowers an urban sanitary authority to provide places of public recreation.

Clause 166 gives power to provide markets.

Clauses 169-170 give power to provide public slaughter-houses, and to regulate private slaughter-houses.

In Schedule IV. of the Act will be found the various legal forms of notice for requiring the abatement of nuisance, summons, etc., but these concern the clerk and sanitary inspector more than they do the medical officer of health.

12. The other Acts which have not been repealed by the Public Health Act, to which reference may be made, are the Artisans' and Labourers' Dwellings' Act, the Bakehouse Regulation Act, and the Baths and Washhouses' Act, but as the essential provisions of these are included in the bye-laws of all urban districts in which they are in force, they need not be further considered here.

In towns containing a population of 25,000 and upwards, as enumerated at the last census, an important duty will devolve upon the medical officer of health of recommending the adoption of the Artisans' Dwellings' Acts of 1875, when any houses, courts, or alleys, within a certain area of his district, are unfit for habitation by reason of their unhealthiness, and when the sanitary defects in such area cannot be effectually remedied otherwise than by an improvement scheme. As the local authority cannot carry out the intentions of the Act without an official representation made by the medical officer of health, and as he is bound by the Act to make such representation whenever he sees cause for the same, it need hardly be said that the duty imposed upon him will demand the utmost care and conscientiousness on his part.

The provisions of the Public Health (Water) Act have already been referred to, and the only other Acts with which the medical officer of health should make himself familiar, are the Sale of Food and Drugs' Act, 1875, and the Canal Boats' Act, 1877. The latter Act empowers the Local Government Board to appoint Sanitary Authorities having districts abutting on a canal as Registration Authorities to register boats and number them, and to fix the number, age, and sex of the persons who may be allowed to dwell in each boat. Regulations are also provided for the separation of the sexes, cleanliness, ventilation, habitable condition, and for preventing the spread of infectious diseases.

13. *Bye-Laws.*—In all urban districts, the medical officer of health will find that bye-laws have already been framed, and as a matter of course he should at once make himself thoroughly acquainted with their details, and more especially with those which relate to the removal of refuse and the prevention of nuisance, the sanitary arrangements of new buildings, and the inspection and regulation of slaughter-houses, bakehouses, and common lodging-houses. Unfortunately, rural sanitary authorities have no power to issue bye-laws with respect to new buildings, etc., unless they are provided with urban powers; but since these can be granted by the Local Government Board, it will become the duty of the medi-

cal officer of health to recommend that an application be made for the granting of such powers, whenever he feels assured that the sanitary requirements of his district demand them. In order that he may be fully qualified to advise the Sanitary Authority with regard to the framing of bye-laws when required, the medical officer of health should make himself thoroughly acquainted with the code of model bye-laws which have been issued by the Local Government Board.

14. *Legal Proceedings.*—Unless under exceptional circumstances, the medical officer of health should never conduct a case before the justices,—that is the duty of the clerk to the sanitary authority, or in respect to common nuisances, it is often discharged by the sanitary inspector. Although he will often have to recommend that proceedings be taken, his duty, so far as the prosecution is concerned, should be confined to furnishing a certificate or giving evidence when required. With a well-trained inspector, it is seldom that he will be required to give evidence except as regards cases of overcrowding, infected houses, or exposure of infected persons, clothing, etc., unsound meat, nuisances which are likely to be contested, and offensive trades.

15. *Routine of Duty.*—This of course will very much depend on the nature and extent of the district. It unfortunately happens that in many instances the appointment of medical officer of health is made under circumstances in which he is expected to do but little, and that little only when called upon by the sanitary inspector to certify or give evidence. But in all large urban or combined districts, it is necessary that the duties should be carried on as systematically as possible. As already stated, the sanitary inspector or inspectors should be under the supervision of the medical officer of health, and any orders from the sanitary authority affecting the

luties of these officials should be conveyed through him ır with his concurrence, otherwise he cannot be held esponsible for the efficient working of his department. The following are the duties of the sanitary inspector as laid down by an order of the Local Government Board, dated November 11, 1872, and they apply to all inspectors who are appointed, subject to the approval of that Board :—

> "The following shall be the duties of the inspector of nuisances in respect of the district for which he is appointed, or if he shall be appointed for more than one district, then in respect of each of such districts :—
>
> "(1.) He shall perform, either under the special directions of the sanitary authority, or (so far as authorised by the sanitary authority) under the directions of the medical officer of health, or in cases where no such directions are required, without such directions, all the duties specially imposed upon an inspector of nuisances by the Sanitary Acts, or by the orders of the Local Government Board.
>
> "(2.) He shall attend all meetings of the sanitary authority when so required.
>
> "(3.) He shall by inspection of the district, both systematically at certain periods, and at intervals as occasion may require, keep himself informed in respect of the nuisances existing therein that require abatement under the Sanitary Acts.
>
> "(4.) On receiving notice of the existence of any nuisance within the district, or of the breach of any bye-laws or regulations made by the sanitary authority for the suppression of nuisances, he shall, as early as practicable, visit the spot, and inquire into such alleged nuisance or breach of bye-laws or regulations.
>
> "(5.) He shall report to the sanitary authority any noxious or offensive businesses, trades, or manufactories established within the district, and the breach or non-observance of any bye-laws or regulations made in respect of the same.
>
> "(6.) He shall report to the sanitary authority any damage done to any works of water supply, or other works belonging to them, and also any case of wilful or negligent waste

of water supplied by them, or any fouling by gas, filth, or otherwise, of water used for domestic purposes.

"(7.) He shall from time to time, and forthwith upon complaint, visit and inspect the shops and places kept or used for the sale of butchers' meat, poultry, fish, fruit, vegetables, corn, bread, or flour, or as a slaughter-house, and examine any animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, or flour, which may be therein; and in case any such article appear to him to be intended for the food of man, and to be unfit for such food, he shall cause the same to be seized; and take such other proceedings as may be necessary in order to have the same dealt with by a justice: Provided that in any case of doubt arising under this clause he shall report the matter to the medical officer of health, with the view of obtaining his advice thereon.

"(8.) He shall, when and as directed by the sanitary authority, procure and submit samples of food or drink, and drugs suspected to be adulterated, to be analysed by the analyst appointed under the Adulteration of Food Act, 1872; and upon receiving a certificate stating that the articles of food or drink, or drugs, are adulterated, cause a complaint to be made, and take the other proceedings prescribed by that Act.

"(9.) He shall give immediate notice to the medical officer of health of the occurrence within his district of any contagious, infectious, or epidemic disease of a dangerous character; and whenever it appears to him that the intervention of such officer is necessary in consequence of the existence of any nuisance injurious to health, or of any overcrowding in a house, he shall forthwith inform the medical officer thereof.

"(10.) He shall, subject in all respects to the directions of the sanitary authority, attend to the instructions of the medical officer of health with respect to any measures which can be lawfully taken by him under the Sanitary Acts for preventing the spread of any contagious, infectious, or epidemic disease of a dangerous character.

"(11.) He shall enter from day to day, in a book to be provided by the sanitary authority, particulars of his inspections and of the action taken by him in the execution of his duties. He shall also keep a book or books, to be provided by the sanitary authority, so arranged as to form, as far as possible, a continuous record of the sanitary condition of each of the premises in respect of which any action has been taken under the sanitary Acts, and shall keep any other systematic records that the sanitary authority may require.

"(12.) He shall at all reasonable times, when applied to by the medical officer of health, produce to him his books, or any of them, and render to him such information as he may be able to furnish with respect to any matter to which the duties of inspector of nuisances relate.

"(13.) He shall, if directed by the sanitary authority to do so, superintend and see to the due execution of all works which may be undertaken under their direction for the suppression or removal of nuisances within the district.

"(14.) In matters not specifically provided for in this order, he shall observe and execute all the lawful orders and directions of the sanitary authority, and the orders of the Local Government Board which may be hereafter issued, applicable to his office."

In some valuable articles which appeared in the *Medical Times and Gazette* in Nov. 1872, on the duties of medical officers of health, the following sketch of the daily routine in a large metropolitan parish is given as a guide for commencing health officers:—

"At 9 A.M. the subordinate officers arrive at the office. They onsist of a clerk, a messenger (who is always a copying clerk), the anitary inspectors, to each of whom a district is assigned, and a isinfector. Shortly after the medical officer arrives, reads his etters, confers with the clerk, gives directions as to the correpondence of the day, receives verbal reports from the inspectors as o the previous day's work, and makes appointments for these fficers to meet him at particular places during the course of the ay, should his presence be deemed necessary in particular cases. n a few minutes a large amount of routine work can thus be got hrough, whilst reports for committees, special correspondence, and he examination of the books of the department, can be despatched, ay twice or thrice a week, at any convenient time. Between 9 nd 10 A.M. each inspector writes out a brief diary of his previous ay's work for the information of the medical officer, and instructs he disinfector as to houses where disinfection is required. At 10 he sanitary inspectors depart on their daily rounds, having previusly informed themselves as to any new complaints requiring their attention. After their departure the clerk extracts and summarises their diaries, and enters the results in the proper books. The books actually in use are—(1.) The medical officer's diary, in which he briefly enters the dates of visits made, with any particulars he thinks fit. (2.) A book for receiving the complaints of ratepayers and others. (3.) A record of houses in which infectious disease has appeared. (4.) The diaries of the several sanitary inspectors. (5.) A book recording the progress of works, which exhibits at a glance the visits made and the works executed at any particular house. From this the clerk extracts, and presents weekly to the medical officer—(6.) A list of works in arrear. (7.) A report book which the health officer reports to the sanitary committee on ordinary cases of nuisances uncompleted, together with his recommendations. Further, the sanitary inspectors are provided with forms of notice of nuisances, arranged in books with duplicates, after the manner of a cheque-book. These arrangements may seem complicated. In practice, however, they are found to be simple and effective. Where little or no clerical assistance is furnished, they may be much simplified, and the books reduced in number.

In small urban or rural districts, and in combined districts when special clerical assistance is not required, the only book which it may be necessary to keep beyond filing statistics, reports, and any important official communications, is a diary, but this should always be kept, no matter how meagre the duties may be, because it will be frequently required for reference.

16. *Reports.*—All reports from the health officer to the sanitary authority should be concise and to the point. The stated reports, weekly, quarterly, or otherwise, will deal chiefly with the vital statistics of the district, and enumerate such proceedings as have been undertaken, according to the provisions of the Sanitary Acts, together with any suggestions which he may deem it to be his duty to lay before the sanitary authority from time to time. He should avoid entering into lengthy disquisitions, because he will have the opportunity, at meetings of the sanitary authority, of answering any questions, and justifying his recommendations, should he be called upon to do

10. As far as possible he should base his stated reports on a uniform plan, and he may be quite sure that the briefer they are in their completeness, the more they will be appreciated. Annual reports should embrace all the points indicated in the regulations of the Local Government Board, previously quoted. (For official instructions see Appendix.)

If his reports appear in the public newspapers of the district, as will generally be the case, he should endeavour, without being diffuse, to make them readable and instructive, and whenever he considers it necessary to address the public through this channel, with respect to any sanitary dangers to which they may be specially exposed, it is always advisable that his remarks should, in the first instance, be submitted to the sanitary authority. Although he will find the press to be of great assistance n educating the public in sanitary matters, it need hardly be said that he should avoid entering into controversy, and that he should be very careful not to drag the names f private individuals before the public when his reports re printed.

17. *Official Conduct.*—With regard to his subordinates, the medical officer should endeavour to arouse in them n *esprit de corps*, not doing their work, but seeing that they do it themselves efficiently and readily. He should listen courteously to any remarks or suggestions which they may make, and if they are trained officers, give them credit for knowing their duties as well as he does his own. In their own sphere they are as sensitive to rebuke as himself, and it should, therefore, never be administered unless it is merited. Any serious delinquency or inefficiency on their part should be laid before the sanitary authority, and those who do perform their duties satisfactorily should be as frankly commended. Above all, punctuality should be insisted on. In cases where the

health officer will have to educate sanitary inspectors who are new to the work, it would be desirable that all candidates for such an important post should pass a certain period of probation before their appointment is confirmed by the sanitary authority.

As regards the portion of the community committe to his charge, he should endeavour conscientiously, an to the best of his ability, to fulfil his obligations toward them, and if in practice, he should in no wise shirk h public duty, even at the risk of losing his best patie In this, as in all other affairs of life and conduct, it w be found that in the long run "honesty is the best polic

Towards his medical brethren he should religiously observe the ethics of his profession, and act up to the golden rule,—"Do to others as you would be done by." He should endeavour to be on friendly terms with all within his district, and never hesitate to court their assistance and advice when he feels that he may require them in the discharge of his duties. It need hardly be said that all such favours or obligations should be readily and ungrudgingly reciprocated on his part. If he is not debarred from private practice, he should be careful, above all things, not to take advantage of his public office by using it as a means to increase the number of his patients. This, to say the least, would be a grave breach of professional etiquette, which would deservedly arouse remonstrance and opposition on the part of his medical brethren.

His relations to the sanitary authority or sanitary committee, as the case may be, should be guided b common sense and a sense of duty. He should alwa remember that he is their medical adviser, not their di tator; and at their meetings he should carefully av taking part in discussions on his reports, unless cal upon to do so, or in reply to objections. He should tend all meetings at which his presence is requeste ected; and when he does attend, he should support views, when called upon, with clearness, firmness, tesy, and tact. His proposals may be rejected, but if do not lie within the scope of the statutory enact-ts requiring their enforcement, he should never resent sition, but again bring them forward on future occa-s. But with regard to breaches of sanitary law, which pite of his representations may be persistently ignored, hould unhesitatingly insist upon their being remedied, failing action, he can always appeal to the Local ernment Board. It is to be hoped, however, that he seldom meet with such unwarrantable opposition. ler all circumstances he should strive to exercise a forbearance when he can conscientiously do so, and ll occasions maintain a courteous, dignified, and friendly eanour towards the sanitary authority, feeling assured tact and good temper, like good words, "are worth h, and cost but little."

APPENDIX.

OFFICIAL MEMORANDA AND OTHER DATA.

—The DAIRIES, COW-SHEDS, and MILK-SHOPS ORDER of 1879, issued 4th February 1879.

1. *Preliminary.*—This Order may be cited as The Dairies, Cow-Sheds, and Milk-Shops Order of 1879.

2. This Order shall take effect from and immediately after the making thereof.

3. This Order extends to Great Britain only.

4. In this Order—

The Act of 1878 means The Contagious Diseases (Animals) Act, 1878;

Other terms have the same meaning as in the Act of 1878.

5. *Registration of Cow-Keepers and others.*—(1.) Every Local Authority shall, with all practicable speed after the making of this Order, open, and shall thenceforth keep, a register for the registration with them under this Order of all persons from time to time arrying on in their district the trade of cow-keepers, dairymen, or purveyors of milk, and shall, from time to time, revise and correct he register.

(2.) The Local Authority shall give public notice, by advertisement in a newspaper circulating in their district, and, if they think it, by placards, handbills, or otherwise, of the time at which the register will be opened, and of the mode of registration.

(3.) After the expiration of the time prescribed in this behalf in the advertisement, not being more than two months, and not being less than fourteen days, from the publication of the advertisement, it shall not be lawful for any person to carry on in the district of the Local Authority the trade of a cow-keeper, dairyman, or purveyor of milk, unless he is registered as such under this Order.

6. *Dairies and Cow-Sheds.*—It shall not be lawful for any person following the trade of cow-keeper or dairyman to begin to occupy as a dairy or cow-shed any building not so occupied at the making of this Order, unless and until he first makes provision, to the reasonable satisfaction of the Local Authority, for the lighting, ventilation, cleansing, drainage, and water-supply, of the same, while occupied as a dairy or cow-shed.

7. It shall not be lawful for any person following the trade of cow-keeper or dairyman to occupy as a dairy or cow-shed any building, whether so occupied at the making of this Order or not, if and as long as the lighting, ventilation, cleansing, drainage, and water-supply thereof are not such as are necessary or proper—

(*a.*) for the health and good condition of the cattle therein; and
(*b.*) for the cleanliness of milk-vessels used therein for containing milk for sale; and
(*c.*) for the protection of the milk therein against infection and contamination.

8. *Cleansing.*—A Local Authority may, from time to time, make regulations for prescribing and regulating the cleansing of dairies and cow-sheds in the occupation of persons following the trade of cow-keepers or dairymen, and the cleansing of milk-stores, milk-shops, and milk-vessels used for containing milk for sale by such persons.

9. *Contamination of Milk.*—If at any time disease exists among the cattle in a dairy or cow-shed, or other building or place, the milk of a diseased cow therein—

(*a.*) shall not be mixed with other milk; and
(*b.*) shall not be sold or used for human food; and
(*c.*) shall not be sold or used for food of swine or other animals, unless and until it has been boiled.

10. It shall not be lawful for any person following the trade of cow-keeper, or dairyman, or purveyor of milk, or being the occupier of a milk-store or milk-shop, to allow any person suffering from a dangerous infectious disorder, or having recently been in contact with a person so suffering, to milk cows, or to handle vessels used for containing milk for sale, or in any way to take part or assist in the conduct of the trade or business of the cow-keeper, dairyman, purveyor of milk, or occupier of the milk-store or milk-shop, as far as regards the production, distribution, or storage of milk, until all danger therefrom of the communication of infection to the milk, or of its contamination, has ceased.

11. It shall not be lawful for a person following the trade of cow-keeper, or dairyman, or purveyor of milk, or being the occupier of a milk-store or milk-shop, to use a milk-store or milk-shop in his

ccupation, or permit the same to be used, for any purpose incom- atible with the proper preservation of the cleanliness of the milk- tore or milk-shop, and of the milk-vessels and milk therein, or in ny manner likely to cause contamination of the milk therein.

C. L. Peel.

II.—Regulations for Houses or Parts of Houses which are Let in Lodgings or Occupied by more than One Family, framed by the Society of Medical Officers of Health, London, 1879.

1. *Registration.*—Every house or part of a house let in lodgings r occupied by members of more than one family, may be registered, d every house so registered is hereinafter referred to as a “regis- red house.” Notice of registration shall be given by the Inspector the owner and the keeper of the registered house, together with copy of these regulations. One month after such notice of regis- ation, these regulations shall come into force, and the owner and e keeper of the registered house, each for his own part only, shall en become, and continue responsible for the observance of the me until he shall have given notice in writing to the Vestry, at eir Office, that he has ceased to be the owner or the keeper of the gistered house, as the case may be, and until he has ceased to be e owner or the keeper. In case the owner does not reside in or ar the district, he shall appoint an agent in or near the registered use, who shall be responsible for the observance of these regu- tions.

The Inspector shall keep at his office a book for the registration registered houses, in which he shall enter such particulars as the estry may direct; and he shall in every case enter therein the me and the address of the owner, or his agent, and of the keeper, the registered house; the number, and the cubical contents of e several rooms, and the number of lodgers authorised to be re- ived in the registered house, and in the several rooms thereof.

2. *Number of Lodgers.*—The keeper of a registered house shall t permit a greater number of persons to live in any room therein an shall be compatible with the allowance of not less than 300 bic feet of space for each adult, provided the room is used solely a day-room, or as a sleeping-room; or 350 cubic feet if the room occupied by day and night. In computing the number of persons at may lawfully occupy any room, two children under the age of 2 years may be counted as one adult. The number of persons ho may lawfully occupy the several rooms in a registered house

shall be specified on a ticket, which shall be given to the keeper at the time when the notice of registration is served upon him. The keeper shall preserve the said ticket in a clean and legible condition, and shall produce it to the Inspector on application.

3. *Separation of Sexes.*—The keeper of a registered house shall not permit persons of opposite sexes to occupy the same sleeping-room, except in the case of a married couple, or parents and children under fourteen years of age, or children only under fourteen years of age.

4. *Rooms that may not be used as Sleeping-Rooms.*—The keeper of a registered house shall not permit any scullery or wash-house, or any flagged room in the basement, or any room having a drain-inlet therein, or any room that is not in strict conformity with the requirements of the 103d section of the Metropolis Local Management Act, to be used as a sleeping-room.

5. *Tenantable Repair.*—The owner of a registered house shall keep all parts thereof in good tenantable repair, and so that the roof shall be water-tight, and provided with proper means for carrying off rain-water. The spout by which it is so carried off shall not be immediately connected with a drain, but shall be so directed as to discharge itself over a trapped grating.

6. *Water Supply.*—The owner of a registered house, not having a constant water-supply, shall cause it to be provided with a cistern, properly placed above ground, constructed of impervious materials, covered with a properly-fitting lid, and provided with an overflow or warning-pipe, which shall not be connected with any soil-pipe, house-drain, or common sewer. The capacity of the cistern shall be in the proportion of ten gallons for every person lawfully occupying the house (in conformity with Reg. 2) over and above the amount required for the supply of the water-closet.

The keeper of the registered house shall cause the cistern to be kept covered, and to be cleansed at least once every two months, and shall exercise due care to preserve the water from contamination.

7. *Drainage.*—The owner of a registered house shall cause it to be drained into the common sewer, when there is a sewer within 100 feet thereof, and he shall cause the main drain of the house to be properly ventilated, and trapped at the point of entrance into the sewer, and all drain-inlets to be properly trapped and covered with irremovable covers to the satisfaction of the inspector.

8. *Privy Accommodation.*—The owner of a registered house shall provide privy accommodation in the proportion of one properly trapped water-closet for every twenty persons lawfully occupying the house (in conformity with Reg. 2). Every water-closet

shall be provided with a properly-fitting door, and all requisite fastenings, and with all requisite water-supply apparatus, and with a sufficient supply of water, so as effectually to flush the same, either from a service-box, or from a cistern independent of the cistern provided for the general water-supply of the house, and shall be well and sufficiently ventilated into the outer air. No waste-pipe from a cistern shall be connected with the basin or trap, or soil-pipe or any part of a water-closet apparatus, and no rain-water pipe shall be connected with the soil-pipe of a water-closet. The soil-pipe shall be of impervious material, and shall be impervious at the joints.

The keeper of a registered house shall cause every water-closet to be kept in a clean and wholesome condition.

9. *Dust-Bin.*—The owner of a registered house shall cause it to be provided with an ash-pit, properly covered, and fitted with a slide or doors, and placed in the best practical position to the satisfaction of the inspector, so as not to be a nuisance, and so as that it may not foul the drinking-water. The ash-pit shall be of sufficient size to contain the dust, ashes, and refuse of the house during a week's accumulation.

The keeper of a registered house shall cause the ash-pit to be kept in a cleanly and wholesome condition and covered, and the doors thereof to be kept closed. The ash-pit shall be emptied once in every week. The keeper, if he refuse to allow the contents of the ash-pit to be removed on application by any properly-appointed dustman, shall be liable to the penalty hereinafter declared.

N.B.—Notice of omission by the dustman to empty the ash-pit on the appointed day of the week should be forwarded by the keeper of the registered house to the inspector, at his office, without delay.

10. *Cleanliness.*—The owner of a registered house shall cause the walls and ceilings of every room, and of the staircases, passages, water-closets, and out-houses thereof, to be thoroughly cleansed; and, where not papered, well and sufficiently whitewashed or coloured once at least in every year, and oftener if required by the Vestry. Papered walls shall be stripped as and when the Vestry shall require, and in all cases after the occurrence of any dangerous infectious disorder in any room in a registered house.

The keeper of a registered house shall cause the floor of every room, and of the passages and staircases thereof, to be swept at least once a day, and to be washed as frequently as necessary, so that the same may be kept at all times in a clean and wholesome condition.

Every lodger who shall fail to comply with the requirements of the keeper to carry out this regulation, shall be subject to the penalty hereinafter declared.

11. *Cellars, Yards, and Areas.*—The owner of a registered house shall cause every yard and area thereof to be properly paved and drained so as to run dry and effectually take off all waste water, and shall limewhite the walls of the area and of the yard (to the height of ten feet) at least once in every year, and oftener if necessary, when required by the inspector.

The keeper of a registered house shall cause every cellar, yard, and area to be properly swept clean every day, and to be well and sufficiently washed and cleansed once in every week, or more frequently if necessary, and shall not allow of the accumulation of any rags, bones, or other offensive refuse, or of the accumulation of any material or things so as to interfere with the sanitary condition of the premises, or with the proper lighting and ventilation of the house.

12. *Ventilation.*—The owner of a registered house shall provide all requisite means for the ventilation of the rooms, passages, and staircases thereof, to the satisfaction of the inspector.

The keeper of a registered house shall cause every room therein, and the passages and staircases thereof, to be thoroughly ventilated daily to the satisfaction of the inspector.

13. *Infectious Diseases: Small-pox, Fever, etc.*—The keeper of a registered house shall give immediate notice to the inspector if any case of illness or death from small-pox, fever, or other dangerous infectious disorder occur therein, and he shall carry out without delay all measures for disinfection which the inspector may direct.

Should any such disease recur in the house and resist the ordinary means for its extirpation, then the house shall be closed for the more effectual cleansing and disinfection of the same for any period not exceeding one calendar month, at the discretion of the medical officer of health.

The keeper of a registered house shall cause the body of any inmate who may die of a dangerous infectious disorder to be removed without delay to the public mortuary.

14. *Animals.*—The keeper of a registered house shall not allow any animal to be kept on the premises so as to render them unclean or unwholesome; or so as to be a nuisance or injurious to health; and he shall remove any such animal forthwith, on receiving a notice to that effect from the inspector.

15. *Inspection: Power of Entry.*—The keeper of a registered house shall allow such house to be inspected by the inspector at any hour between eight in the morning and eight in the evening; and any person refusing to admit him, or obstructing him in the execution of his duty, shall be liable to the penalty hereinafter declared.

16. *Notices.*—All notices required by these regulations to be served on the owner or the keeper of a registered house shall be sufficiently served by being left at, or attached to some part of, the house; and in the case of a house not registered may be addressed "to the owner" or "to the keeper" of the house without naming him.

Penalties.—The penalty for violation of any of the above regulations shall not be less than five nor more than forty shillings, with an additional penalty of not less than five nor more than twenty shillings for every day during the continuance of the offence.

III.—MEMORANDUM on HOSPITAL ACCOMMODATION, to be given by LOCAL AUTHORITIES.—(See Chap. X.)

IV.—AMBULANCES.

FOR the conveyance to hospital of patients who are sick with infectious disease, special carriages, which are known by the name of "ambulances," are necessary. Such carriages may be provided by sanitary authorities under § 24 of the Sanitary Act, 1866.[1] The following points have to be attended to in the provision and use of such carriages:—

1. If the ambulance be intended only for journeys of not more than a mile, it may be made so as to be carried between two people, or it may be on wheels and to be drawn by hand. If the distance be above a mile, the ambulance should be drawn by a horse. Every ambulance on wheels should have easy carriage-springs.

2. In the construction of an ambulance, special regard should be had to the fact that after each use it has to be cleansed and disinfected. The entire interior, and the bed-frame and bed, should be of materials that can be washed.

3. The ambulance should be such that the patient can lie full length in it; and the bed-frame and bed should be movable, so that the patient can be arranged upon the bed before being taken out of his house.

4. With an ambulance there should always be a person specially in charge of the patient; and a horse-ambulance should have a seat for such person inside the carriage.

5. After every use of an ambulance for infectious disease, it should be cleansed and disinfected to the satisfaction of a medical officer.

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[1] § 123 of the Public Health Act, 1875.

6. Both in very populous districts, and in districts which are of very wide area, it may often happen that more than one ambulance will be wanted at one time; and, in any district, if more than one infectious disease is prevailing, there will be an evident sanitary advantage in having more than one ambulance for use.

JOHN SIMON.

Medical Department of the Local Government Board,
December 1874.

V.—RULES drawn up by the AUTHOR for the SOLIHULL HOSPITAL for INFECTIOUS DISEASES.

RULES FOR MEDICAL OFFICER, MASTER, AND MATRON.

1. The Medical Officer shall be the responsible head of the establishment, and shall visit occasionally, even when there are no patients, to assure himself that the master and matron are attending to their duties.

2. It shall be the duty of the master and matren to keep the wards scrupulously clean, and to have the bedding well aired and in readiness at all times for the reception of patients. They shall keep an inventory of everything belonging to the hospital, and a careful record of the articles of food and drink supplied to patients by the order of the medical officer or other medical attendant. One of them shall always be at the hospital, unless when special leave is granted by the sanitary authority or their clerk. They shall obey the instructions of the medical officer, and be responsible for the good conduct of nurses and patients.

3. The master shall attend the board meetings at Solihull at least once a month, to submit his books and take orders for necessaries. By order,

EDWARD ORFORD SMITH,
Solihull, 31*st October* 1877. *Clerk to the said Authority.*

RULES FOR PATIENTS AND FRIENDS.

1. No person shall be admitted to the hospital without the production of a certificate signed by a duly qualified medical practitioner.

2. Any patient admitted into the hospital may be attended by any qualified medical practitioner, provided that a request to this effect is submitted to the medical officer or sanitary inspector at the time of admission, and that the cost of such attendance is defrayed by the patient or friends.

3. No visitor shall be allowed inside the building or grounds without written permission from the medical officer.

4. No patient shall leave the wards, or take exercise in the grounds ithout permission from the medical officer or medical attendant.

5. Any patient leaving the hospital, without the written permission of the medical officer or medical attendant, will be liable to heavy penalties, which will be enforced by the sanitary authority.

6. No patient shall leave the hospital without a change of lothes, unless the clothing used during convalescence has been carefully disinfected.

7. No person in attendance upon patients shall leave the hosital without permission from the medical officer, nor without a hange of clothes. By order,

EDWARD ORFORD SMITH,
olihull, 31*st October* 1877. *Clerk to the said Authority.*

I.—MEMORANDUM on the STEPS specially requisite to be taken by BOARDS of GUARDIANS under the VACCINATION ACTS 1867 and 1871, in places in which SMALL-POX is EPIDEMIC.

As it is by vaccination that the spread of small-pox can most ffectually be prevented, Boards of Guardians, as soon as any case f that disease is brought into or occurs in their respective Unions r Parishes, should see that measures are promptly taken to secure, s far as necessary, the vaccination (or, as the case may be, re-vacination) of all such persons as are especially exposed to the danger f the infection.

Under the Order of Privy Council of February 18, 1868 (Reg. . Art. 1), the public vaccinator is authorised to vaccinate, elsewhere han at the public station, cases in which there exists a special eason (to be noted by him in his register) for taking this excepional course; and sec. 13 of 34 and 35 Vict. cap. 98, provides hat district medical officers in attendance upon any person sufferng from small-pox shall be entitled to payment from the Guardians or vaccinating or (as the case may be) re-vaccinating any person who is resident in the same house as such sick person, and who ould lawfully be vaccinated or (as the case may be) re-vaccinated y a public vaccinator at the public expense.

These provisions, promptly applied on the occurrence of any solated case or cases of small-pox, will in general be found adequate to stop the further spread of the disease; but if from neglect of them or from any other circumstance cases of small-pox shall have become numerous, special measures (as below explained) should be taken to expedite, as far as practicable, the vaccination of all unvaccinated persons in the district, and to promote the re-vaccination of adults and adolescents who have not already been successfully re-vaccinated; and special arrangements (as below explained) may also be requisite to facilitate the performance of public vaccination and re-vaccination.

This Memorandum is intended to afford information on those measures and arrangements.

I.—*Special Instructions to Vaccination Officers.*

1. At times when small-pox is epidemic, the vaccination officer should give his first and special attention to the particular localities in which the infection exists.

2. In order that for this purpose he may have the earliest possible information of the occurrence of cases of the disease, the Guardians should instruct their district medical officers to give him immediate notice of every fresh case of small-pox which comes under their treatment, and should also arrange with the registrars of deaths to forward to him immediate notice of each death registered from small pox. For convenience of transmitting such notices, each district medical officer and Registrar should be supplied with forms duly stamped for post, or with post-cards adapted for the purpose. Private medical practitioners should also be invited to give similar information.

3. In each locality in which the infection exists, the vaccination officer should with the utmost possible despatch personally ascertain what children are unprotected by vaccination, and should use his utmost exertions to obtain the prompt vaccination of all such children. Generally speaking, his own judgment and local knowledge will guide him as to the manner in which his inquiries can best be made; but in infected courts or alleys, as well as certain kinds of streets, inquiries from house to house, and, in tenement-houses, from room to room, will be indispensable.

4. Where any child (between the ages of 3 months and 14 years) is found illegally unvaccinated, the vaccination officer should give a notice requiring the vaccination to be done within a specified period. This period, when there is small-pox in the house, or other special risk of exposure to the contagion, should not exceed twenty-four hours; but in other cases some days, not exceeding a week, may be allowed. A second visit from the vaccination officer will, of course, afterwards be necessary in order to see that his notice has been complied with.

With regard to unvaccinated children not yet three months old, who may be in infected localities, the vaccination officer should dvise the parents not to incur the unnecessary risk of waiting for he child to complete that age before having its vaccination per- ormed; for vaccination is perfectly well borne by children even mmediately after birth. In no house in which there is small-pox ught a child, however young, on any account to remain unvaccinated, unless on medical examination it be pronounced unfit to be vaccinated.

5. The vaccination officer should make it well known in infected localities that the public vaccinator is at liberty to re-vaccinate grown-up and young persons (not under 12 years of age) who have not before been successfully re-vaccinated, and who apply to him or that purpose; and that persons not vaccinated since childhood, who are likely to be exposed to contagion, ought to be re-vaccinated without delay. Above all, this is necessary for persons whose riginal marks of vaccination are imperfect.

6. All notices given and representations made as above should e accompanied with information as to the provisions made for ublic vaccination in the district. If any case requiring prompt accination by the public vaccinator cannot, in the judgment of the accination officer, properly be taken to the station or to the resi- ence of the public vaccinator, the vaccination officer should give to he public vaccinator immediate information of the case.

7. Besides the above described special proceedings in localities lready infected, the vaccination officer should take every means to nsure that the vaccination of his district generally is as complete s possible. He should make frequent examination of his birth- ists, and deal, as soon as practicable, with every default as it rises; and he should be prompt and diligent in his inquiries especting the other children to whom his duties extend under ection 12 of his "instructions," as issued by the Local Government Board.

II.—*Special Arrangements for Public Vaccination.*

1. In towns which have regular weekly attendances for the per- ormance of public vaccination, the only modification usually requisite will consist in the vaccinators giving special daily attendances at the station at a fixed hour for the vaccination of cases of emergency.

[Where the town-district is of particularly large population (so that the ordinary average weekly number of primary vaccinations performed at the stations exceeds twenty), it may be convenient that during the stress of the epidemic the station should be open for the general performance of vaccination on two days (instead of one day) in each week.]

It must, however, be distinctly understood that the daily attendances given as above are *only* for cases of emergency; and that cases which are not of emergency must be left to the times of general vaccination.

It is on the regular weekly attendances that the vaccinator has to depend not only to maintain the usual performance of primary vaccination from arm to arm, but also to furnish lymph for cases of re-vaccination and for use in his special attendances ; and the experience of every recent epidemic of small-pox has shown that to attempt at such times an indiscriminate daily performance of vaccination and re-vaccination leads only to difficulties and disadvantages. There are two reasons, indeed, for which at such times an adherence to systematic arrangements (with exception only for special cases) is of more than ordinary consequence ; first, because it is then peculiarly important that each primary vaccination should be done under conditions which scarcely admit of failure ; and, secondly, because without system it is quite impossible properly to meet the large demands for re-vaccination which at such times are sure to arise. Re-vaccinations, unless of persons residing in houses in which there is small-pox, or under other exceptional circumstances, should always be reserved for the regular vaccinating days.

2. In districts (whether of town or country) which ordinarily have their public vaccinations performed at quarterly or half-yearly or other intervals, should small-pox break out at a time of year when vaccination is not going on, it will be necessary that the station for the district, or part of district, in which the disease is prevailing should at once be opened, and that a weekly attendance should be given thereat for a limited period ; during which period the vaccination officer should take steps as above directed for making the vaccination of the district, or part of district, as complete as possible. In districts of the kind now under consideration it will probably be more convenient that cases of emergency should be vaccinated at their own homes under the exceptional provisions of Regulation 1, Article 1, of the Order of Feb. 18, 1868 (above referred to) than that daily attendances should be given at the station.

3. Any exceptional vaccination arrangements made as above by the guardians with reference to epidemics of small-pox should be for some fixed period, not exceeding six weeks ; at the end of which period they can, in case of need, be renewed by a further order of the Guardians ; but every such making or renewal of the exceptional arrangements should be reported without delay to the Local Government Board.

N.B.—The isolation of the sick, the disinfection of infected houses, and the disinfection or destruction of infected things, are very important means of checking the spread of small-pox ; and in order that such measures may be enforced, the Public Health Act, 1875, besides imposing penalties on the exposure of infected persons, the letting of infected houses, the sale of infected things, and other acts similarly dangerous to the public health, gives very important powers to sanitary authorities. These are stated in the official "Memorandum on the duties of sanitary authorities in reference to epidemics of small-pox." It is also to be observed that, so far as the destitute classes are visited by small-pox, boards of guardians, as poor law authorities, have opportunities, which it is desirable they should fully use, for securing disinfection and the isolation of the sick.

EDWARD C. SEATON, M.D.,
Medical Officer.

Local Government Board, March 1877.

VII.—MEMORANDUM for the Assistance of GUARDIANS and others in framing and carrying out Arrangements for the Performance of PUBLIC VACCINATION.

PUBLIC VACCINATION.

Vaccination Acts, 1867 *and* 1871.
Regulations of 1*st December* 1859, *and*
Regulations of 18*th February* 1868.

1. In order to secure the best sort of vaccination, the operation should, as far as practicable, be performed with fresh lymph direct from arm to arm. The lymph should be carefully selected from the best-formed vesicles upon the healthiest children at the right period of the course of the vesicles. And the arrangements for public vaccination under the vaccination contracts ought to be framed so as to secure, as far as possible, these objects.

2. As, in ordinary circumstances, it is at the end of the week from vaccination that the arm of a child is in the state best fitted for yielding lymph, the attendances for the performance of public vaccination must be given at weekly intervals.

3. As, for keeping up vaccination in perfection it is essential that a public vaccinator should have on each vaccinating occasion a large choice of children and of vesicles, it is obvious that the cases for vaccination must not be divided between too many stations, or distributed over too many vaccinating days.

4. It is only in very populous districts that weekly vaccination can be maintained efficiently throughout the year. If an attempt were made to keep up vaccination throughout the year at a vaccination

station to which (say) 100 cases are brought annually, it would be found that as the births are not equally spread over the whole year, and as accidental circumstances must often interfere with the bringing of children in particular weeks, there would not unfrequently be no cases at all at the station to supply lymph, and in the majority of weeks not a sufficient number of children to enable the vaccinator to make a proper selection.

5. Hence, in districts which are not very populous, it is necessary that public vaccination should be performed at certain periods of the year, as at quarterly or half-yearly periods, weekly attendances being then given for two, three, four, or more successive weeks, according to the population for the accommodation of which the particular station is designed.

6. Without attempting to lay down a precise rule on a question which must largely be decided according to the circumstances of each locality, it may be said, generally, that any station at which there are less than 80 vaccinations annually should not be attended more frequently than at half-yearly periods.

7. Provision is made by the 12th section of the Vaccination Act, 1867, by which, in districts in which public vaccination is performed at intervals exceeding three months, parents of children attaining the age of three months do not become liable to penalty for the non-vaccination of their children until after the next public vaccination held in the district subsequently to their having attained that age.

8. Children living within two miles of a vaccination station cannot (unless under special circumstances) legally be vaccinated by the public vaccinator except at the station, and at the time specified in the contract. If, however, some special reason require this rule to be departed from in any particular case, an entry stating the "special reason" must, in accordance with the Regulations of 18th February 1868, be made in the vaccinator's register.

9. Having regard to weather and to other considerations, the months of April and October will generally be found most suitable for half-yearly vaccination.

10. In framing periodical arrangements for districts in which there are two or more stations, the attendances should not commence in the same week at all the stations, but a week or two should be given for establishing at the most frequented station a supply of lymph with which to start vaccination at the others.

11. It is convenient that, as far as practicable, the stations of a district should be attended on the same week day, in order that, when necessary, lymph may be taken fresh from station to station.

12. In districts in which public vaccination is fixed to take

place periodically, the public vaccinator should, on the day week preceding the first day of the periodical attendances appointed under Schedule A. to the contract, vaccinate with lymph stored by himself or obtained from the National Vaccine Establishment, or some other trustworthy source, two or three selected children. Arrangements should be made for bringing these children to the station on the day appointed for beginning the periodical vaccination of the district, and the lymph from their arms will afford means of starting such vaccination satisfactorily. The public vaccinator in registering these vaccinations should, in accordance with Regulation 1 of 18th February 1868, state in his register the special reason for their not having been vaccinated at the station.

13. By section 7 of the Vaccination Act, 1867, it is provided that all vaccination stations (except at the residence or surgery of the public vaccinator) shall be provided by the guardians.

14. Vaccination stations must be within the district for which they are to serve, and must not be fixed at union workhouses, as the independent poor are unwilling to resort for vaccination to an institution connected with pauper relief. The same objection applies, though perhaps in a minor degree, to the appointment of pauper pay stations as vaccination stations. The Board further consider it undesirable that public-houses should be selected for the purpose. Whatever room or place be selected as a vaccination station, it is essential that the public vaccinator should have the exclusive use of it during the time of vaccination.

15. In large towns the vaccination station should, if possible, be at some public building, *e.g.* town hall, meeting hall, or school, or at rooms specially hired for the purpose. Various objections exist to the use of the surgeries of public vaccinators in such towns, especially that they rarely afford the accommodation necessary for the number of children likely to be brought, and that they do not possess the distinctive public character which is desirable.

16. In rural districts schoolrooms are frequently found convenient for the purpose. It is of course necessary that the assent of the managers of the school should be obtained; that the vaccination should be fixed at such an hour as not to interfere with school arrangements; and particularly that the public vaccinator should have at the time fixed for vaccination the exclusive use of the schoolroom or class-room appointed for the purpose.

17. In order to secure at vaccination stations the punctual bringing together of children (from some of whom lymph has to be taken for the vaccination of others), it is desirable that the time of attendance notified to parents should be that at which vaccination is intended to begin, as "at 10 A.M.," not "from 10 to 11 A.M."

18. The hour of public vaccination should never be fixed so late in the day as to make it impracticable to complete the business of the station by daylight.

19. Enough time (which should rarely be less than one hour) should be allowed between the times of attendance at different stations to enable the public vaccinator, after performing vaccination and making the necessary entries in the register at one station, to arrive punctually at the next.

20. The payments to be made for vaccinations performed at other places than stations, should not in any case exceed the sum that would have been paid had the operation been performed at the station nearest to the residence of the person vaccinated.

21. Every vaccination contract must contain a stipulation or condition in accordance with section 7 of the Vaccination Act, 1867. The form in general use is as follows :—

A

And it is hereby mutually agreed by and between the parties hereto, that no money shall be paid to the said
in respect of any person vaccinated by him until he shall have transmitted to the vaccination officer a certificate of the successful vaccination of such person, and otherwise fulfilled on his part the requirements of the Vaccination Acts, 1867 and 1871, and the regulations made thereunder.

22. The course to be taken if small-pox break out in a district where ordinarily the public vaccination is carried on periodically, is explained in the Office Memorandum on the steps to be taken by guardians in places in which small-pox is epidemic.

23. If an infectious disease, such as scarlatina, measles, or diphtheria, prevail to such an extent in a district that the public vaccinator considers that the bringing of children together for vaccination would be likely to spread the disease, he should represent the facts to the Guardians for communication with the Board, who will, on sufficient cause shown, be ready to authorise the postponement of the attendances prescribed by the contract.

24. A contractor for public vaccination must be a registered medical practitioner qualified in medicine and surgery, and (if admitted to practice since 1st January 1860) possessing a special certificate of proficiency in vaccination from one of the Examiners authorised to grant such certificates for the purposes of the Order of 1st December 1859.

25. The duties of a public vaccinator must be habitually discharged by the contractor himself, and the employment of a

deputy must be limited to those occasions when unavoidable circumstances prevent the contractor's personal attendance.

26. In order to provide for occasions when the public vaccinator is unavoidably absent, it is proper that a deputy (who must possess the same qualifications as a contractor) should be appointed under the Regulations of 1st December 1859, and that the appointment, after being submitted by the Guardians for the approval of the Local Government Board, should be endorsed upon the contract. It must be understood, however, that the approval of such appointment is not to be taken as authorising any habitual omission on the part of the public vaccinator to perform in person the duties for which he is responsible.

27. Public vaccination cannot under any circumstances be legally performed by an unqualified person, and the guardians cannot legally pay for any vaccination so performed.

E. C. SEATON, M.D.
Medical Officer.

Local Government Board, 1st January 1879.

VIII.—RE-VACCINATION.

By vaccination in infancy, if thoroughly well-performed and successful, most people are completely insured for their whole lifetime against an attack of small-pox; and in the proportionately few cases where the protection is less complete, small-pox, if it be caught, will, in consequence of the vaccination, generally be so mild a disease as not to threaten death or disfigurement. If, however, the vaccination in early life have been but imperfectly performed, or have from any other cause been but imperfectly successful, the protection against small-pox is much less satisfactory; neither lasting so long, nor, while it lasts, being nearly so complete as the protection which first-rate vaccination gives. In consequence of the large amount of imperfect vaccination which has till very recent years existed, the population contains very many persons who, though nominally vaccinated and believing themselves to be protected against small-pox, are really liable to infection, and may in some cases contract as severe forms of small-pox as if they had never been vaccinated. Partly because of the existence of this large number of imperfectly vaccinated persons, and partly because also even the best infantine vaccination sometimes in process of time loses more or less of its effect, it is advisable that *all persons who have been vaccinated in infancy should, as they approach adult life, undergo* RE-VACCINATION. Generally speaking, the best time of life for re-vaccination is about the time when growth is completing itself, say from 15 to 18 years of age; and persons in that period of life ought not to delay their re-vaccination till times when there shall be special alarm of small-pox: first, because they can never tell how soon, or by what chance, they may (even at times when there is little prevalence of that disease) be exposed to its infection; and secondly, because of the much more advantageous conditions under which the re-vaccination can be performed when it can be done leisurely, than when it has to be done under the pressure caused by a panic. When, however, small-pox becomes epidemic, not only should all persons above 15 years of age who had hitherto neglected to have themselves re-vaccinated be very careful to neglect it no longer, but in proportion as there is prevalence of small-pox in any neighbourhood, or as individuals are from personal circumstances likely to meet chances of infection, even the age of 15 should not be waited for, especially not by young persons whose marks of previous vaccination are unsatisfactory. *The rule applicable to circumstances of special danger is this: that every one past childhood on whom re-vaccination has not before been successfully performed, should without delay be re-vaccinated.*

Re-vaccination, once properly and successfully performed, *does not appear ever to require repetition.* The nurses and other servants of the London Small-Pox Hospital, when they enter the service (unless it be certain that they have already had small-pox), are invariably submitted to vaccination, which in their case generally is re-vaccination, and is never afterwards repeated; and so perfect is the protection, that though the nurses live in the closest and most constant attendance on small-pox patients, and though also the other servants are in various ways exposed to special chances of infection, the resident surgeon of the hospital, during his forty-one years of office there, has never known small-pox affect any one of these nurses or servants.

Legal provisions for re-vaccination are made in the 8th Section of the Vaccination Act, 1867, in Section IV. of the Regulations which the Lords of the Council under authority of that Act issued in their Order of February 18, 1868, and in the 9th Section of the Vaccination Act, 1871. Under these provisions, *Re-vaccination is now performed by all public vaccinators at their respective vaccinating-stations;* and, so far as is not inconsistent with the more imperative claims for primary vaccination, *any person coming within the terms of these provisions may, on applying to the public station of the district in which he resides, obtain re-vaccination free of personal cost.*

EDWARD C. SEATON, M.D.,
Medical Officer.

Local Government Board, October 17, 1876.

Section VIII. of the Vaccination Act, 1867, is as follows:— "The provisions of the contracts entered into before this Act comes into operation shall not, after the thirty-first day of December next, apply to the cases of persons who, having been previously successfully vaccinated, shall be re-vaccinated; but if the Lords of Her Majesty's Council shall have issued or shall hereafter issue regulations in respect of the re-vaccination of persons who may apply to be re-vaccinated, which such Lords are hereby authorised to do, the guardians shall pay, in respect of every case of successful re-vaccination performed in conformity with such regulations under such contracts or under new contracts entered into after the date hereof, a sum amounting to two-thirds of the fee payable upon each case of successful primary vaccination."

Section IV. of the Regulations issued by the Lords of the Council in their Order of February 18, 1868, is as follows:—"The performance of re-vaccination by the public vaccinator on persons applying to him for that purpose shall be limited in each case by the following conditions—(1) that, so far as the public vaccinator can ascertain, the applicant has attained the age of fifteen years, or if, during any immediate danger of small-pox, the age of twelve years, and has not before been successfully re-vaccinated; and (2) that, in the public vaccinator's judgment, the proposed re-vaccination is not for any sufficient medical reason undesirable; and (3) that the public vaccinator can afford vaccine lymph for the purpose without in any degree postponing the claims which are made on him for the performance of primary vaccination in his district."

Section IX. of the Vaccination Act, 1871, is as follows:— "Where the operation of re-vaccinating any person is performed on the application of such person by the public vaccinator without charge to such person, the public vaccinator shall deliver to such person a notice requiring him to attend at the same place on the same day in the following week, in order that he may be inspected and the result of the operation ascertained, and stating that in default he will be liable as in this section mentioned, and the public vaccinator, if required, shall deliver to the person re-vaccinated a certificate of the result of the operation of re-vaccination; and if such person fail to comply with such notice, or to permit the public vaccinator or his deputy to ascertain the result of the operation, he shall pay a fee for such re-vaccination of two shillings and sixpence, which fee shall be a debt due from him to the guardians of the union or parish in which such public vaccinator acts, and all such fees shall be paid to and all expenses of the guardians incurred under this section shall be paid out of the fund out of which the expenses of the guardians under the principal Act are paid."

IX.—GENERAL MEMORANDUM on the PROCEEDINGS which are advisable in PLACES attacked or threatened by EPIDEMIC DISEASE.

1. Wherever there is prevalence or threatening of cholera, diphtheria, fever, or any other epidemic disease, it is of more than common importance that the statutory powers conferred upon Sanitary Authorities for the protection of the public health should be well exercised by those Authorities, acting with the advice of their medical officers of health.

2. Proper precautions are equally requisite for all classes of society. But it is chiefly with regard to the poorer population, therefore chiefly in the courts and alleys of towns, and at the labourers' cottages of country districts, that local authorities are called upon to exercise vigilance, and to proffer information and advice. Common lodging-houses, and houses which are sub-let in several small holdings, always require particular attention.

3. Wherever there is accumulation, stink, or soakage of house refuse, or of other decaying animal or vegetable matter, the nuisance should as promptly as possible be abated, and precaution should be taken not to let it recur. Especially examination should be made as to the efficient working of sewers and drains, and any nuisance therefrom, or from any foul ditches or ponds, should be got rid of without delay. The ventilation of sewers, the ventilation and trapping of house drains, and the disconnection of cistern overflows and sink pipes from drains should be carefully seen to. The scavenging of the district, the state of receptacles for excrement, and of dustbins, will require particular and sustained attention. In slaughter-houses, and wherever animals are kept, strict cleanliness should be enforced.

4. In order to guard against the harm which sometimes arises from disturbing heaps of offensive matter, it is often necessary to combine the use of chemical disinfectants (see § 17) with such means as are taken for the removal of filth; and in cases where removal is for the time impossible or inexpedient, the filth should always be disinfected. Disinfection is likewise desirable for unpaved earth close to dwellings, if it be sodden with slops and filth. Generally, where cholera or enteric (typhoid) fever is in a house, the privy requires to be disinfected.

5. Sources of water-supply should be well examined. Those which are in any way tainted by animal or vegetable refuse, above all, those into which there is any leakage or filtration from sewers,

drains, cesspools, or foul ditches, ought no longer to be drunk from. Especially where the disease is cholera, diarrhœa, or enteric fever, it is essential that no foul water be drunk.

If unfortunately the only water which for a time can be got should be open to suspicion of dangerous organic impurity, it ought at least to be boiled before it is used for drinking, but then not to be drunk later than twenty-four hours after it has been boiled. Or under medical or other skilled direction, water, in quantities sufficient for one day's drinking in the house, may be disinfected by a very careful use of Condy's red disinfectant fluid; which should be added to the water (with stirring or shaking) in such number of drops that the water, an hour afterwards, shall have the faintest pink colour which the eye can distinctly perceive. Filtering of the ordinary kind cannot by itself be trusted to purify water, but is a good addition to either of the above processes. It cannot be too distinctly understood that dangerous qualities of water are not obviated by the addition of wine or spirits.

When there appears any probable relation between the distribution of disease and of milk supplies, the cleanliness of dairies, and the purity of the water used in them, should be carefully investigated.

6. The washing and lime-whiting of uncleanly premises, especially of such as are densely occupied, should be pressed with all practicable despatch.

7. Overcrowding should be prevented. Especially where disease has begun, the sick-room should, as far as possible, be free from persons who are not of use or comfort to the patient.

8. Ample ventilation should be enforced. It should be seen that window-frames are made to open, and that windows are sufficiently opened. Especially where any kind of infective fever has begun, it is essential, both for patients and for persons who are about them, that the sick-room and the sick-house be constantly well traversed by streams of fresh air.

9. The cleanliest domestic habits should be enjoined. Refuse matters which have to be cast away should never be allowed to remain within doors; and things which have to be disinfected or cleansed should always be disinfected or cleansed without delay.

10. Special precautions of cleanliness and disinfection are necessary with regard to infective matters discharged from the bodies of the sick. Among discharges which it is proper to treat as infective, are those which come, in cases of small-pox, from the affected skin; in cases of cholera and enteric fever, from the intestinal canal; in cases of diphtheria, from the nose and throat; likewise, in cases of any eruptive or other epidemic fever, the general exhalations of

the sick. The caution which is necessary with regard to such matters must, of course, extend to whatever is imbued with them; so that bedding, clothing, towels, and other articles, which have been in use by the sick, may not become sources of mischief, either in the house to which they belong, or in houses to which they are conveyed. Moreover, in enteric fever and cholera, the evacuations should be regarded as capable of communicating an infectious quality to any night-soil with which they are mingled in privies, drains, or cesspools; and this danger is best guarded against by thoroughly disinfecting them before they are thrown away (see § 17); above all, they must never be cast where they can run or soak into sources of drinking water.

11. All reasonable care should be taken not to allow infective disease to spread by the unnecessary association of sick with healthy persons. This care is requisite, not only with regard to the sick house, but likewise with regard to day schools and other establishments wherein members of many different households are accustomed to meet.

12. Where dangerous conditions of residence cannot be promptly remedied, it will be best that the inmates, while unattacked by disease, remove to some safer lodging. If disease begins in houses where the sick person cannot be rightly circumstanced and tended, medical advice should be taken as to the propriety of removing him to an infirmary or hospital. Every sanitary authority should have in readiness a hospital for the reception of such cases.

13. Privation, as predisposing to disease, may require special measures of relief.

14. In certain cases special medical arrangements are necessary. For instance, as cholera in this country almost always begins somewhat gradually in the comparatively tractable form of what is called "premonitory diarrhœa," it is essential that, where cholera is epidemic, arrangements should be made for affording medical relief without delay to persons attacked, even slightly, with looseness of bowels. So again, where small-pox is the prevailing disease, it is essential that all unvaccinated persons (unless they previously have had small-pox) should very promptly be vaccinated; and that revaccination should be performed in cases properly requiring it.

15. It is always to be desired that the people should, as far as possible, know what real precautions they can take against the disease which threatens them, what vigilance is needful with regard to its early symptoms, and what (if any) special arrangements have been made for giving medical assistance within the district. For the purpose of such information printed hand-bills or placards may usefully be employed, and in cases where danger is great, house-to-

house visitation by discreet and competent persons may be of the utmost service, both in quieting unreasonable alarm, and in leading or assisting the less educated and the destitute parts of the population to do what is needful for safety.

16. The present memorandum relates to occasions of emergency. Therefore the measures suggested in it are all of an extemporaneous kind ; and permanent provisions for securing the public health have not been in express terms insisted on. It is to be remembered, however, that in proportion as a district is habitually well cared for by its sanitary authorities, the more formidable emergencies of epidemic disease are not likely to arise in it.

17. Chemical disinfectants are of two great classes, and hitherto it is not certain which of the two classes acts best. The one class is well represented by chlorine and certain of its compounds ; the other is well represented by carbolic acid. Under the former system, the solution of chloride of lime may be used for minor domestic purposes, chloride of lime itself to any masses of filth, and chlorine gas for disinfection of rooms. Under the latter system carbolic acid may be used for minor domestic purposes, sulphate or perchloride of iron to any masses of filth, and sulphurous acid gas for disinfection of rooms. These systems do not combine well with one another, and in the choice which has to be made between them, it will be convenient that the sanitary authority of each district should declare which of the two systems it adopts, and that all private disinfection in the district should follow such lead of the authority. The detail in each case should be carried out under medical advice. In public disinfection establishments for the disinfection of wearing apparel, bedding, curtains, and other large household articles, the most convenient process consists in employment of high degrees of heat.

EDWARD C. SEATON, M.D.,
Local Government Board, January 1878. *Medical Officer.*

X.—SUGGESTIONS by the SOCIETY of MEDICAL OFFICERS of HEALTH, for Preventing the Spread of Infectious or Contagious Diseases, such as SCARLET FEVER, SMALL-POX, FEVER, etc.

1. Separate the sick person from the rest of the family directly illness appears, placing him, if possible, in a room at the top of the house, and taking care to remove carpets, curtains, and all unnecessary articles *of furniture* and clothing therefrom.

2. Admit fresh air by opening the upper sash of the window. The fireplace should be kept open, and a fire lighted if the weather permits. Fresh air should be freely admitted through the whole house by means of open windows and doors. The more air that passes through the house, the less likely is the disease to spread.

3. Hang up a sheet outside the door of the sick-room, and keep it wet with a mixture made either with a quarter of a pint of carbolic acid (No. 4), or a pound of chloride of lime, and a gallon of water.

4. Everything that passes from the sick person should be received into vessels containing half a pint of a solution of green copperas, made by dissolving one pound of the copperas in a gallon of water. A like quantity of the solution of copperas should be added to the discharges before emptying them into the closet.

5. Every sink, closet, or privy should have a quantity of one of the above-named disinfectants poured into it daily, and the greatest care should be taken to prevent the contamination of well or drinking water by any discharges from the sick person.

6. All cups, glasses, spoons, etc., used by the sick person should be first washed in the above-named solution of carbolic acid, and afterwards in hot water, before being used by any other person.

7. No article of food should be allowed to remain in the sick-room. No food or drink that the sick person has tasted, or that has been in the sick-room, should be given to any one else.

8. All bed and body linen, as soon as removed from the sick person, and before being taken from the room, should be first put into a solution of carbolic acid of the above-mentioned strength, remaining therein for at least an hour, and afterwards boiled in water.

9. Instead of handkerchiefs, small pieces of rag should be used, and these, when soiled, should be immediately burnt.

10. Persons attending on the sick should not wear woollen garments, as they are likely to retain infectious poison; dresses of cotton, or of some washable material, should be worn. Nurses should always wash their hands immediately after attending to the sick person, using carbolic acid soap instead of ordinary soap.

11. It is of the utmost importance that the sick-room be not frequented by others than those in immediate attendance on the sick, as the clothing of visitors is very liable to carry away infection.

12. The scales and dusty powder which peel from the skin in scarlet fever, and the crusts in small-pox, being highly infectious, their escape may be prevented by smearing the body of the sick person all over every day with camphorated oil. This, and the after use of warm baths and carbolic acid soap, are most essential.

The sick person must not be allowed to mix with the rest of the family until the peeling has *entirely ceased*, and the skin is perfectly smooth; clothes used during the time of illness, or in any way exposed to infection, *must not be worn again until they have been properly disinfected*.

13. When the sickness has terminated, the sick-room and its contents should be disinfected and cleansed. This should be done in the following manner:—Spread out and hang upon lines all articles of clothing and bedding; well close the fireplace, windows, and all openings; then take a quarter to half a pound of brimstone, broken into small pieces; put them into an iron dish, supported over a pail of water, and set fire to the brimstone, by putting some live coals upon it. Close the door, and stop all crevices, and allow the room to remain shut up for twenty-four hours. The rooms should then be freely ventilated, by opening the door and windows, the ceiling should be white-washed, the paper stripped from the walls and burnt, and the furniture, and all wool and painted work be well washed with soap and water containing a little chloride of lime. Beds, mattresses, and articles which cannot well be washed, should, if possible, be submitted to the action of heat in a disinfecting chamber, usually provided by the local authorities. *Until this process of disinfection is effectually carried out, the room cannot be safely occupied.*

14. Children should not be allowed to attend school from a house in which there is infectious disease, as, although not ill themselves, they are very likely to carry the infection, and so spread the disease. No child should be allowed to re-enter a school without a certificate from the medical attendant, stating that he can do so without any danger of infecting other children.

15. In case of death, the body should not be removed from the room, except for burial, unless taken to a mortuary, nor should any article be taken from it until disinfected as before directed in Rule No. 13. The body should be put into a coffin as soon as possible, with a pound or two of carbolic powder. The coffin should be fastened down, and the body buried without any delay.

Attention is particularly directed to the following provisions of the Sanitary Laws, in reference to "Infectious Disorders:"—

1. The owner or occupier may be required to cleanse and disinfect any house or room, or the cabin or berth of any ship or vessel, and the articles contained in it likely to retain infection—where

infectious disease has existed—under a penalty not exceeding 10s. a day for neglect.

2. If any person, suffering from any dangerous infectious disorder, shall enter a cab or other public conveyance, without informing the driver thereof that he is so suffering, he shall be liable to a penalty not exceeding £5.

3. Any person suffering from any dangerous infectious disorder—such as fever, scarlet fever, small-pox, etc.—who exposes himself in any street, school, church, chapel, theatre, or other public place; or in any omnibus or other public conveyance; and any person in charge of one so suffering, who so exposes the sufferer, shall be liable to a penalty not exceeding £5.

4. Any person who, without previous disinfection, gives, lends, sells, or moves to another place, or exposes any bedding, clothing, rags, or other things which have been exposed to infection, becomes liable to a penalty not exceeding £5.

5. Any person who lets a house, room, or part of a house, in which there has been infectious disease, without having such house or room, and all articles therein liable to infection, disinfected to the satisfaction of a qualified medical practitioner, is liable to a penalty not exceeding £20. This applies to public-houses, hotels, and lodging-houses.

6. If any person who lets, or shows for hire, any house or part of a house, makes any *false statement* as to the fact of there being then in such house, or having within six weeks previously been therein, any person suffering from an infectious disease, such person *answering falsely* shall be liable to imprisonment, with or without hard labour, or to a penalty not exceeding £20.

J. NORTHCOTE VINEN, M.D.
St. John's, Southwark,
W. H. CORFIELD, M.D. (Oxon.)
10 *Bolton Row, Mayfair,*
} *Hon. Secs.*

March 1875.

XI.—MEMORANDUM with respect to RETURNS of DEATHS from Registrars and RETURNS of PAUPER SICKNESS from District Medical Officers.

Under Articles 14 and 15 of Section IV. of the General Order of the 11th November 1872, every medical officer of health whose appointment has been approved by the Board is required to prepare an annual report, comprising amongst other things, tabular statements of the mortality and of the pauper sickness in his district

Information as to mortality and sickness is required by the medical officer of health not only in preparing these statements, but also in discharging the duties of his office, and this Memorandum is intended to indicate the arrangements which should be made for furnishing him with such information.

I. The sanitary authority should, under section 28 of the Births and Deaths Registration Act, 1874, require the Registrars of Births and Deaths to supply returns of the deaths registered within their respective districts. These returns should be made weekly as regards all deaths registered as having occurred within the Registrar's district during the preceding week ; but an immediate notice should be given of all deaths from infectious disease in fresh localities, and of all groups of deaths from such disease, or from diarrhœa, in any localities. The Registrar-General has prepared for the use of Registrars a form in which the weekly returns may be conveniently made. A fee of twopence for each entry is payable by the Sanitary Authority.

II. The medical officer of health should be regularly supplied with information of the new cases of pauper sickness in his district. This information is valuable to him, not only as an index to the prevalence of non-fatal disease among all classes in the sanitary district, but as giving him occasion to exercise useful and immediate sanitary supervision over localities which are most apt to require such supervision. It is requisite for this object, as well as to enable him to complete the annual returns, that (except where the medical officer of health is himself the Poor-Law medical officer for the whole sanitary area under his superintendence, in which case he will of course possess this information) the guardians should instruct their clerk to copy from the district medical officer's relief lists the new cases which are reported at each meeting of the guardians, and to forward the same promptly and regularly to the medical officer or officers of health within the union. Arrangements should be made for the regular transmission of the copies referred to as early as practicable after each meeting. It is competent to the sanitary authority, whether rural or urban, to pay a reasonable sum to the clerk to the guardians for the supply of this information.

III. The guardians should request the Poor-Law medical officers to give to the medical officer of health (or to the inspector of nuisances, for the information of the medical officer of health) acting within their respective districts, the earliest possible information of cases of dangerous infectious disease under their charge ; as it is evident that unless such information is given as soon as the cases occur, the action of the sanitary authority in regard to the prevention of infection may often fail in its effect.

IV. Under the Board's General Order of the 12th February 1879, it is incumbent upon all district and workhouse medical officers appointed since the 28th February 1879, to furnish the medical officer of health with returns of pauper sickness and deaths, as well as to notify the outbreak of dangerous infectious disease. A similar obligation has been imposed by the Board's Order of the 14th June 1879 upon medical officers of district schools appointed after the 25th June 1879. JOHN LAMBERT, *Secretary.*

Local Government Board, 20th July 1879.

XII.—ANNUAL REPORTS of MEDICAL OFFICERS of HEALTH.

Instructions.—Every medical officer of health, appointed under the order of the Local Government Board dated the 11th November 1872, is required to make an annual report with regard to each sanitary district, or division of a district, which is under his superintendence. This report is to be for the year ending the 31st of December, or, if the officer at that date has not been in office for a whole year, then for so much of the year as has elapsed since his appointment. The report is to be made to the sanitary authority, and a copy of it is to be sent by the medical officer of health to the Local Government Board. It should be made as soon as practicable after the expiration of the year to which it relates. The medical officer of health ought not, in general, to have any difficulty in doing this within a month or six weeks; but if from any special circumstances the report cannot be completed within six weeks, it should be understood that the delay must not be indefinite, and that the report, complete or incomplete, should be in the hands of the sanitary authority within, at most, three months from the end of the year. The Board's copy of the report should be forwarded to them when the original is sent to the sanitary authority, except where the report is likely to be printed by order of the authority. In such cases the Board need only be supplied with a printed copy. But in all cases in which the report cannot be sent to the Board within six weeks from the end of the year, they should be informed by the medical officer of health as to the reason for the delay.

Article 14 of Section IV. of the Board's Order provides that the annual report is to contain information as to the sickness and deaths that have occurred during the year; the measures taken in order to prevent the spread of disease; and the proceedings of the medical officer of health. It would be well if the report, so far as it relates to the medical officer of health's proceedings, were, in the main, the same in arrangement as the articles which deal with these proceedings; thus stating first what has been done under articles 1-3, which make it the duty of the medical officer of health to inform himself as to the sanitary state of the district, and to make the inquiries and inspections necessary for this purpose; next, the advice which has been given to the sanitary authority under articles 4 and 5; and, lastly, the action he has taken under articles 6-10 in the several matters therein referred to.

As regards the duties imposed under these several articles, each of which will thus be reported on, special attention should be had to the provisions of article 3, which directs systematic inspections of the district to be made by the Medical Officer of Health, apart from the inquiries which under other articles of the Order he has to make into particular outbreaks of disease, or into unwholesome conditions to which his attention may have been specially called by complaints or otherwise. The object of these systematic inspections is that the medical officer of health may assure himself that he is well acquainted with all the discoverable circumstances which are likely to affect the public health in his district. How often these inspections require to be made, and how detailed the inquiries should be, must be determined by the particular circumstances of the locality. In some neighbourhoods a house-to-house inspection should as far as practicable be made; in others this may not be needful; but every medical officer of health should at certain times set himself to examine into the state of his district, devoting some time to each portion of it, so as to be sure that no part escapes his notice. In making such an inspection the medical officer of health will usually require the assistance of the inspector of nuisances. Of these inspections, of the judgment he has formed thereon as to the sanitary state of the district, and of the advice he has in consequence given to the sanitary authority, and the action taken by the authority thereon, the annual report should contain a full account.

As regards the tabular statements of sickness and mortality (forms for which statements are now issued by the Board) only one observation appears to be needful. The district under the superintendence of a medical officer of health will often contain several parts evidently differing in their circumstances, or having very different death rates, either of all registered deaths, or of those from some particular disease or class of diseases. The observation of these differences can scarcely fail to lead to valuable information, and it is in view of those differences that in article 14 the tabular statements are required to be classified according to *localities*, and that provision for such a classification is made in the enclosed forms for returns of deaths. In the absence of any ascertained differences of the above sort, it will still be desirable to classify the deaths of the district according to the part of the district in which they occur ; and for this purpose any areas of known population (such as parishes, groups of parishes, townships, or wards) may be taken as representing "*localities*" for the purposes of the Order. Classification on this basis will be likely to lead to the discovery of real differences when the returns for several years can be compared together.

Having regard to the imperfect character of the information which is obtainable as to non-fatal sickness, such a classification cannot, it seems, be generally attempted in the sickness returns; but in particular cases medical officers of health may be able, and may find it useful, so to classify the pauper sickness of which they receive information.

What has been said above with regard to the information which an annual report should contain must be understood, not as suggesting that the report should be limited to these subjects, or that more detailed or differently arranged tabular statements may not be added, but as indicating the minimum of information which will satisfy the requirements of the Board's Order. Many medical officers of health will doubtless, and with great advantage to the administration of their district, give much more detailed information than they are actually required to furnish, and will give especial prominence to the questions to which they have been led by the circumstances of the past year to devote particular attention, or in the investigation of which they may have arrived at valuable conclusions. Any information of this kind will be gladly received by the Local Government Board.

EDWARD C. SEATON, M.D.,
Medical Officer.

Local Government Board, December 1877.

XIII.—Clerk's Fortnightly Return to the Medical Officer of Health of all new Cases of Sickness and Deaths appearing from time to time in the Report Books of the several District Medical Officers of the ______ Union. (*Author's Form.*)

Fortnight ended ______ 187

Name.	Age.	Residence.	Disease.	In-door.	Out-door.	Deaths.	Remarks.

Date,

Signed,

Clerk to the Guardians.

Note.—Forms for the births and deaths registered during the week to be forwarded to the medical officer of health can be obtained from Messrs. Knight and Co., 90 Fleet Street, London ; Shaw and Sons, Fetter Lane, London ; and Farrant and Frost, Merthyr-Tydfil.

XIV.—NOTICE of INFECTIOUS DISEASES occurring amongst PAUPERS. (*Author's Form.*)

________________SANITARY AUTHORITY.

Return of District Medical Officer.

Name.	Age.	Residence.	Disease.	Probable Cause.	Steps recommended.

To be folded and forwarded, unsealed, to Sanitary Inspector.

Signed,

District Medical Officer.

Date,

Return of Sanitary Inspector.

Sanitary Condition of Premises.	Action taken.

To be folded and forwarded, unsealed, to Medical Officer of Health.

Signed,

Sanitary Inspector.

Date,

Explanatory Note.—The above form should be printed on paper foolscap size, with the Returns of the District Medical Officer and Sanitary Inspector on one side, and the addresses of the Medical Officer of Health and Sanitary Inspector on the other.

V.—REPORT of the SOCIETY of MEDICAL OFFICERS of HEALTH on the STATISTICAL RETURNS in the ANNUAL REPORTS of MEDICAL OFFICERS of HEALTH.

The attention of the Society was, some time since, directed to he desirability of an uniform system being adopted in the Statistial Returns of Metropolitan medical officers of health; and the llowing Resolution was agreed to:—"That it be referred to the ouncil to consider as to the desirability of the Statistical Returns the Annual Reports of the Metropolitan medical officers of health eing based on an uniform system, and to frame suggestions for arrying out such a system, if found desirable."

The consideration of the subject was afterwards enlarged, in rder to make the system practicable for *all* medical officers of ealth in London and the country, and the tables recommended by he Council were framed with that object.

The Council was assisted in its deliberations by the statistical nformation given in the Annual Reports of both Metropolitan and rovincial medical officers of health by some retired medical officers f health, and eminent sanitarians.

The Recommendations of the Council were finally adopted by he Society at the last May meeting.

The Society is unanimously of opinion that it is desirable the tatistical returns of all medical officers of health in England and ales should be based on an uniform system, and the following bles are put forth as skeleton models which may be, and it is oped will be, adopted by all medical officers of health. The bles are no doubt susceptible of improvement; but their adoption the present form is urged, as it is believed that any disadvantages ey may possess are outweighed by the advantages resulting from uniform system which admits of the direct comparison of the atistical returns of two or more districts. It is not intended that ese tables *only* should be used by medical officers of health, but hat at least the information here sketched out may be given for all istricts, and in the form here set forth. Other tables may be added t the discretion of medical officers of health.

It is thought desirable, and asked that:—

1. All statistical returns may be made out to the end of the egistration year, as defined in the Registrar-General's Reports (Dec. 31st, or thereabouts).

2. That merely for the sake of uniformity and convenience of

compilation the head of columns for tables be as far as possible identical with those used in the Registrar-General's tables.

3. That the numbers of the tables adopted by the Society be in all cases appended to these tables when used ; and that, to avoid confusion, different numbers be assigned to any other tables which it may be thought fit to insert in an annual report.

The following explanations of the purport of the several tables may be of service :—

TABLE I.—This table merely gives gross numbers, and the statistics of the year under notice, and the ten preceding years, *when these are attainable.*

TABLE II.—This is a table of death rates, and of deaths (gross) in public institutions. It is, like Table I., also retrospective; and it is hoped that as many of the statistics of back years may be given as it is possible to obtain.

TABLE III.—This is an abbreviated copy of the Registrar-General's long table, which is deemed unnecessary to set out at full length. The " etc. etc.," below the word " Syphilis " at the bottom of the first column means that the long list of diseases set out in Registrar-General's table is to be inserted in *full.*

TABLE IV.—This relates to the year under notice only, and needs no further explanation.

TABLE V.—This table is intended to afford a comparison of the mortality from the chief zymotic diseases of the year under notice with that of the antecedent years.

TABLE I.—*Population, Inhabited Houses, Births, Deaths, and Marriages.*

(GROSS NUMBERS.)

Population estimated at the middle of the Year 18 *	No. of Inhabited Houses in Parish or District.	Births.	Deaths.†	Marriages.
1873.				
1872........................	....	....	....	....
1871........................	....	....	....	....
1870........................	....	....	....	....
1869........................	....	....	....	....
1868........................	....	....	....	....
1867........................	....	....	....	....
1866........................	....	....	....	....
1865........................	....	....	....	....
1864........................	....	....	....	....
1863........................	....	....	....	....
Average of 10 years, 1863–1872............				

NOTES.

1. Population at Census 1871.................
2. Area in Acres.................
3. Average No. of Persons in each house at Census 1871..............

---

* For statistical purposes the Registrar-General estimates the population to the middle of the year as the basis of the rate of increase ruling between the two preceding Census periods. The estimate of population may be checked by the known number of inhabited houses, and by the average number of inmates per house, as ascertained at the preceding Census.

† The deaths of non-parishioners in public institutions within the parish should be deducted, but a proportion of the deaths occurring in General Hospitals, relative to the population of the parish or district, should be added to the total number of deaths in this column.

TABLE II.—*Annual Rate of Mortality, Death Rates among Children, and Deaths in Public Institutions.*

	Annual Rate of Mortality per 1000 living.	Deaths of Children under 1 year: percentage to Total Deaths.	Percentage of Deaths of Children under 1 year to Registered Births.	Deaths of Children under 5 years: per cent to total Deaths.	Percentage of Deaths in Public Institutions.
1873.					
1872					
1871					
1870					
1869					
1868					
1867					
1866					
1865					
1864					
1863					
Average of 10 years, 1863-1873					

the Deaths in Public Institutions of Non-residents being excluded.

CAUSE OF DEATH. Classes.	AGES.														TOTAL.
	0 to 1	1 to 2	2 to 5	5 to 15	15 to 25	25 to 35	35 to 45	45 to 55	55 to 65	65 to 75	75 to 85	85 to 95	95 and upwards.	Total under 5 Years.	
I. Zymotic Diseases															
II. Constitutional Diseases															
III. Local Diseases															
IV. Developmental Diseases															
V. Violent Deaths															
Not specified or ill defined															
TOTALS															
I. Zymotic Diseases.															
Order 1.—*Miasmatic.*															
Smallpox															
Measles															
etc. etc.															
Other Zymotic Diseases															
Order 2.—*Enthetic.*															
Syphilis															
etc.															
etc.															

NOTE.—This Table is a copy of that used by the Registrar-General, and is to be extended to other diseases beyond those enumerated.

TABLE IV.—*Showing Mortality from certain classes of Diseases, and proportions to Population, and to* 1000 *Deaths,* 187 , *viz.*—

	Total Deaths.	Deaths per 1000 of Population.	Proportion of Deaths to 1000 Deaths.
1. Seven Principal Zymotic Diseases	....	....	....
2. Pulmonary Diseases......... (*other than Phthisis*)	....	....	....
3. Tubercular Diseases.........	....	....	....
4. Wasting Diseases of Infants	....	....	....
5. Convulsive Diseases of Infants	....	....	....

NOTES.

1. Includes Smallpox, Measles, Scarlet Fever, Diphtheria, Whooping Cough, Fever, and Diarrhœa.

3. Includes Phthisis, Scrofula, Rickets, and Tabes.

4. Includes Marasmus, Atrophy, Debility, Want of Breast Milk, and Premature Birth.

5. Includes Hydrocephalus, Infantile Meningitis, Convulsions, and Teething.

TABLE V.—*Showing the Number of Deaths in the* 10 *years* 186   *to* 187   , *from the seven principal Zymotic Diseases, and the Number in* 187   .

DISEASE.	1863.	1864.	1865.	1866.	1867.	1868.	1869.	1870.	1871.	1872.	Annual Average of 10 years, 1863-1872.	Proportion of Deaths to 1000 Deaths in 10 years, 1863-1872.	1873.	Proportion of Deaths to 1000 Deaths in 1873.
Smallpox														
Measles														
Scarlet Fever														
Diphtheria														
Whooping Cough														
Fever														
Diarrhœa														
Total														
LONDON														
ENGLAND AND WALES														

TABLE VI.—*Inspector's Report of the Sanitary Work, etc., completed in the Year ending December* 31, 187 .

Total.	*e.g.* Regent's Park.	*e.g.* Oxford Street.	*e.g.* Gray's Inn.	*e.g.* Camden Town.	Sub-Districts.		
					No. of Complaints received during the year.		
					No. of Houses and Premises, etc., inspected.		
					Orders issued for Sanitary Amendments of Houses and Premises.		Results of Inspection.
					Houses and Premises, &c., Cleansed, Repaired, and Whitewashed.		
					Houses Disinfected after Infectious Diseases.		
					Repaired, Cleansed, etc.		House Drains.
					Trapped or Ventilated.		
					Repaired, Cleansed, etc.		Privies and W.C.'s.
					Supplied with Water.		
					New provided.		
					New provided.		Dust Bins.
					Repaired, Covered, &c.		
					Cisterns (new) erected.		Water Supply.
					Cisterns Cleansed, Repaired, and Covered.		
					No. of Lodging Houses registered under 35th Clause of Sanitary Acts, 1866.		Miscellaneous.
					No. of Dust Complaints received and attended to.		
					Removal of Accumulation of Dung, Stagnant Water, Animal and other Refuse.		
					Removal of Animals improperly kept.		
					Bakehouses.	Regularly Inspected.	
					Licensed Cowhouses.		
					Licensed Slaughterhouses.		
					Other Proceedings, *e.g.* Legal Proceedings.		

NOTE.—Intended for use in London, but may be modified according to circumstances for the country.

J. NORTHCOTE VINEN, M.D., St. John's, S.E. } *Honorary*
THOS. STEVENSON, M.D., 21 Caversham Road, N.W. } *Secretaries.*

June 1874.

XVI.—Comparison of the Metrical with the Common English Measures, as regards Capacity and Weight, from Tables arranged by Mr. Warren de la Rue, F.R.S.

MEASURES OF CAPACITY.	In Cubic Inches.	In Cubic Feet = 1728 Cubic Inches.	In Pints = 34·65923 Cubic Inches.
Millilitre, or cubic centimetre .	0·061027	0·0000353	0·001761
Centilitre, or 10 cubic centimetres	0·610271	0·0003532	0·017608
Decilitre, or 100 cubic centimetres	6·102705	0·0035317	0·176077
Litre, or cubic decimetre . .	61·027052	0·0353166	1·760773
Decalitre, or centistere . .	610·270515	0·3531658	17·607734
Hectolitre, or decistere . .	6102·705152	3·5316581	176·077341
Kilolitre, or stere, or cubic metre	61027·051519	35·3165807	1760·775314
Myriolitre, or decastere . .	610270·515194	353·1658074	17607·734140

1 cub. in. = 16·3861759 cub. centimetres. 1 cub. ft. = 28·3153119 cub. decimetres.
1 fluid oz. = 28·4 c.c. 1 gallon = 4·543457969. 1 quart = 1·136 litre.

MEASURES OF WEIGHT.	In English Grains.	In Troy Ounces = 480 Grains.	In Avoirdupois Lbs. = 7000 Grains.
Milligramme	0·015432	0·000032	0·0000022
Centigramme	0·154323	0·000322	0·0000220
Decigramme	1·543235	0·003215	0·0002205
Gramme	15·432349	0·032151	0·0022046
Decagramme	154·323488	0·321507	0·0220462
Hectogramme	1543·234880	3·215073	0·2204621
Kilogramme	15432·348800	32·150727	2·2046213
Myriogramme	154323·488000	321·507267	22·0462126

1 Grain = 0·064798950 Gramme. 1 lb. Avd. = 0·45359265 Kilogr.
1 Troy oz. = 31·103496 Gramme. 1 Cwt. = 50·80237689 Kilogr.

XVII.—List of Apparatus and Re-agents.

The following sets of apparatus and re-agents mentioned in different parts of the work may be obtained from various manufacturing chemists, such as Messrs. Griffin and Sons, Garrick Street, Covent Garden, London ; Messrs. Townson and Mercer, Bishopgate Street, London ; Messrs. Sutton, Norwich ; and Messrs. Harris and Co., Bull Ring, Birmingham. The prices quoted are of course subject to variation, and only approximately accurate :—

	About		
Chemical Balance	£3	15	0
Set of Gramme Weights, 50 Grammes to 1 Milligramme (Oertlings)	1	15	0

For the Examination of Air.

1-1 Litre Measure graduated into c.c.	0	9	0
4 Glass Jars to hold 5000 c.c. each	1	2	0
1 India-rubber Caps for ditto (double set)	1	16	0
1 Tall narrow Glass, marked to measure 30 and 60 c.c.	0	2	3
1 Mohr's Burette 50 c.c. graduated into 1-10th	0	5	9
1 Support for ditto (Mahogany)	0	5	0
1 Bellows Pump with long nozzle (length sufficient to reach the bottom of the jars)	0	4	6
2 Mixing Jars 1 Pint	0	2	6
6 Glass Stirrers for ditto	0	0	9
4 oz. Turmeric Paper	0	0	6
1 Box of Filter Papers	0	2	0
1 Glass Funnel 4″	0	0	4
4 oz. Pure Cryst. Oxalic Acid	0	1	4
1 lb. Calcium Hydrate (for making lime water)	0	1	1
2 Common wet and dry bulb Thermometers (Mason's) each	0	9	0

For the Qualitative Examination of Water.

2 Tall colourless glass Cylinders 2 ft. high 1″ diam.	0	10	0
1 Wide mouth colourless glass Flask to hold about 1000 c.c.	0	1	0
1 Nest (12) of Test Tubes	0	1	6
1 Nest Porcelain Evaporating Basins, 2, 4, 8, and 16 oz.	0	3	6
1 Porcelain Crucible 2¼″ diam.	0	10	0

		About	
1 Set (6) Clark's Test Glasses 1 oz.	£0	1	6
1 Set (6) Cylindrical Test Glasses 2 oz.	0	2	0
Apparatus for making sulphuretted hydrogen water (pint)	0	5	0
6 oz. Sol. Caustic Potash	0	2	1
6 „ „ Ammonium Oxalate	0	1	10
6 „ „ Barium Nitrate	0	1	4
6 „ „ Silver Nitrate	0	3	4
6 „ „ Nessler's Test Solution	0	2	5
6 „ „ Ammonia, strong	0	1	4
6 „ „ Acetic Acid	0	2	4
6 „ „ Nitric Acid, dilute	0	1	10
6 „ „ Sulphuric Acid, pure conctd.	0	2	1
6 „ „ Hydrochloric Acid, dilute	0	1	7
2 „ Potassium Iodide	0	1	4
2 „ Potassium Permanganate	0	1	4
6 „ Ferrous Sulphide lumps	0	0	3
2 „ „ Sulphate	0	1	7

For the Quantitative Analysis of Water.

Balance and Weights as above.

1 Liebig's Condenser with stand	0	15	0
2 Retorts, each	0	3	6
1 Retort Stand	0	7	0
2 Burettes 50 c.c., and graduated 1-10th, each	0	3	6
1 Burette 50 c.c., and graduated 1-10th with glass stop-cock	0	7	6
2 Pipettes, 2 c.c., each	0	0	6
2 Pipettes, 5 c.c., graduated 1-10th, each	0	1	6
2 Half-litre Flasks, each	0	1	6
2 Flasks to hold 70 c.c., each	0	1	0
2 Flasks to hold 35 c.c., each	0	0	6
6 Nessler Glasses, 50 c.c., each	0	1	6
1 Platinum Dish	4	0	0
1 Bunsen Burner	0	2	0
1 Wash-bottle	0	1	6
Nitrate of Silver, pure per oz.	0	4	0
Permanganate of Potash „	0	0	8
Caustic Potash „	0	0	6
Soap test (Clark's) per lb.	0	4	0
Nessler Re-agent „	0	6	0
Chloride of Ammonium per oz.	0	0	6
Chromate of Potash „	0	0	3

For the Examination of Milk.

		About		
1	Lactometer graduated to test approximately the percentage of adulteration with water (in a case)	£0	3	0
1	Tall narrow glass vessel graduated to test percentage of cream (in a case)	0	2	0

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THE END.

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